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JOURNAL

VOLUME 13, NUMBER 5 ◆ MAY, 1957

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Engineering A Plastics House

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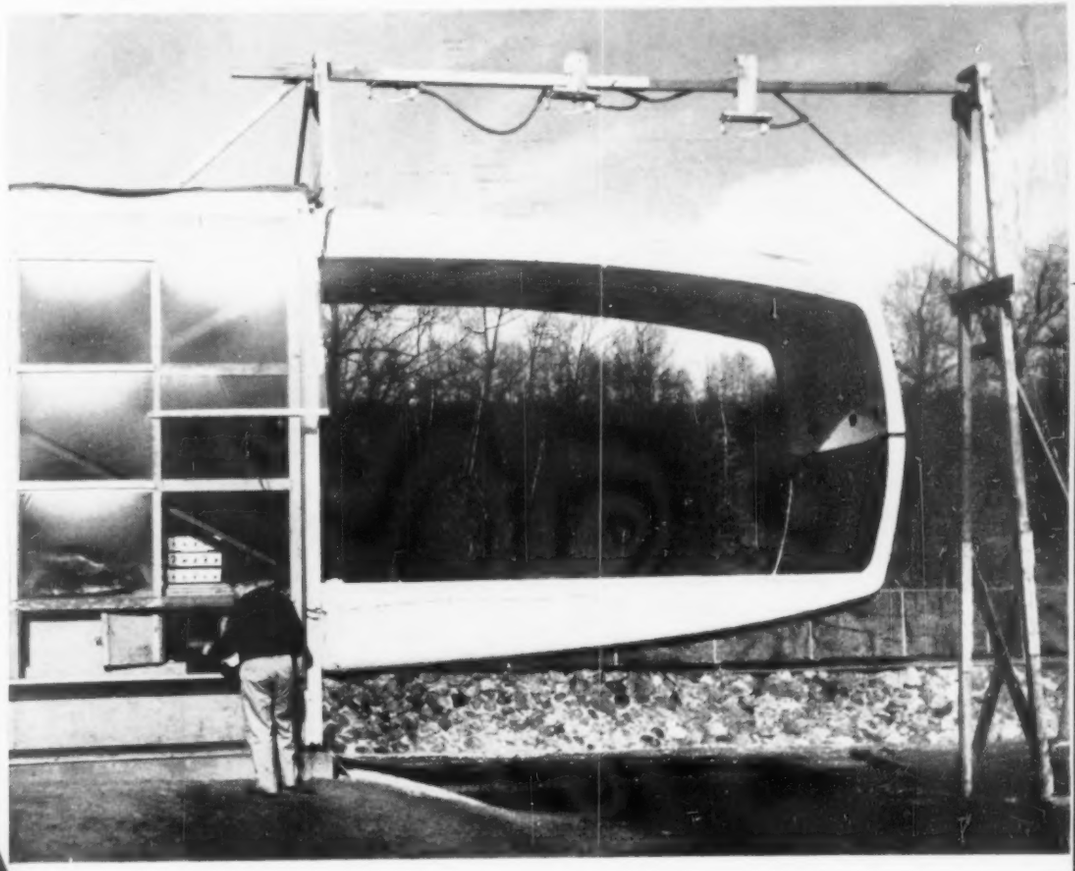
Story on page 38



PUBLISHED BY THE SOCIETY OF PLASTICS ENGINEERS, INC.

Check these proven advantages of

Du Pont Lucite® acrylic resin

- superior thermal stability
- superior flow
- superior cut
- superior moldability

Because customers have been molding parts of Du Pont LUCITE 140 since its introduction in July 1956, it is now possible to describe the advantages of this newly formulated acrylic resin in terms of practical applications.

Customers report that LUCITE 140 demonstrates superior thermal stability and flow previously unobtainable with any acrylic resins of a similar service temperature range. This greater thermal stability permits use of 20° F. to 30°F. higher cylinder temperature. Over the entire molding range, LUCITE 140 provides thicker sections free from bubbles and thinner sections without surface blemishes. The superior flow of LUCITE 140 oftentimes allows for a faster molding cycle and in some molds permits shorter injection time. The greater fluidity of LUCITE 140 also permits smaller gates and consequently less trimming of the molded piece.

The combination of greater thermal stability and increased flow of LUCITE 140 allows lower ram pressures and, in some cases, permits the shot to be more easily ejected from the mold.

In addition, customers cite certain advantages of LUCITE 140 which are a result of the new particle shape called "diamond cut." The advantages of this new cut include: more uniform feed, reduced storage requirements because of higher bulk density, easier handling by pneumatic conveyor systems, less drying necessary, lower fines content and easier handling by weigh feeder.

LUCITE 140 is used for molded parts for service above 180°F. For molds requiring greater ease of filling, the established general-purpose LUCITE 129 and soft-flow LUCITE 130 are available.

Proven in a wide variety of applications, the outstanding advantages of LUCITE 140 have won enthusiastic customer approval. Perhaps these advantages can be helpful to you in your operation. For more property and application data, write to E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 453, Du Pont Building, Wilmington 98, Del.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

Constructed With Sturdy, Dependable

ADVANCE REGISTRATION CARD
NEW ENGLAND REGIONAL CONFERENCE
"PLASTICS FOR ELECTRONICS"
Lowell Technological Institute
Lowell, Massachusetts
June 14, 1957

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for our shell material.

he capital outlay we needed for this was relatively low, and we found he benefit of prior manufacturing : first weeks of production, we were able to turn out a consistently uniform product. All things considered, the use of RCI POLYLITE reinforced with fibrous glass has cut our production costs at least 75%."

be able to withstand the pressures of 100-foot dives ... must be able to resist the corrosive effect of the sea ... and must still be light enough for a man to carry the unit out of the water. These are just some of the physical requirements that must be met for such a product as this ... and met at a price that doesn't take the product out of the sportsman's reach!

"That's why we chose a combination of RCI POLYLITE and fibrous glass," states Felix Aimonetti, vice president and general manager of Link. "From the standpoint of design, engineering and cost, reinforced POLYLITE was

Products possessing the unique advantages of RCI POLYLITE — lightweight strength, durability, and easy maintenance — are becoming increasingly popular and profitable in today's market. Perhaps POLYLITE polyester resin can be incorporated into one of your products. For additional information about what you can do with RCI POLYLITE in laminating, molding or other plastics applications, write for free *Booklet A*.

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Your Partner in Progress

RCI

REICHHOLD

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
Formaldehyde • Glycerine • Phthalic Anhydride • Maleic Anhydride • Sebacic Acid
Sodium Sulfite • Pentaerythritol • Pentachlorophenol • Sulfuric Acid
REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

Check these proven advantages of

Du Pont Lucite® acrylic resin

- superior thermal stability
- superi
- superi
- super

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DU PONT
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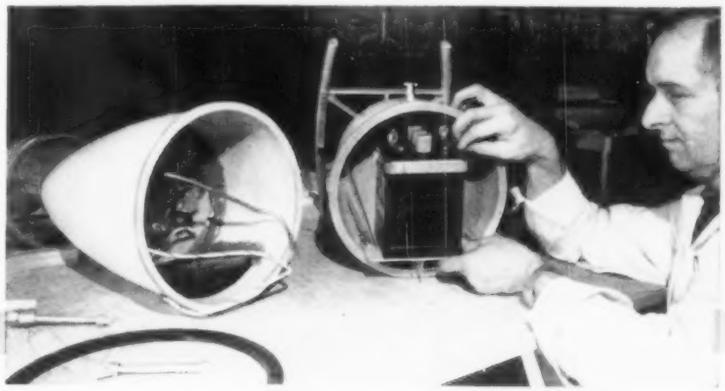
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Constructed With Sturdy, Dependable

POLYLITE

Resin



● Top performance under tough conditions . . . that's what's required of these one man underwater propulsion units made by the Link Aeronautical Corporation of Endicott, New York.

The basic shell material for this "Power Diver" must be able to withstand the pressures of 100-foot dives . . . must be able to resist the corrosive effect of the sea . . . and must still be light enough for a man to carry the unit out of the water. These are just some of the physical requirements that must be met for such a product as this . . . and met at a price that doesn't take the product out of the sportsman's reach!

"That's why we chose a combination of RCI POLYLITE and fibrous glass," states Felix Aimonetti, vice president and general manager of Link. "From the standpoint of design, engineering and cost, reinforced POLYLITE was the perfect solution for our shell material.

"Besides all this, the capital outlay we needed for this type of construction was relatively low, and we found that even without the benefit of prior manufacturing know-how during the first weeks of production, we were able to turn out a consistently uniform product. All things considered, the use of RCI POLYLITE reinforced with fibrous glass has cut our production costs at least 75%."

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Your Partner in Progress

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REICHHOLD

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
Formaldehyde • Glycerine • Phthalic Anhydride • Maleic Anhydride • Sebacic Acid
Sodium Sulfite • Pentaerythritol • Pentachlorophenol • Sulfuric Acid

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

POLYETHYLENE PROCESSING TIPS

Vol. II, No. 3

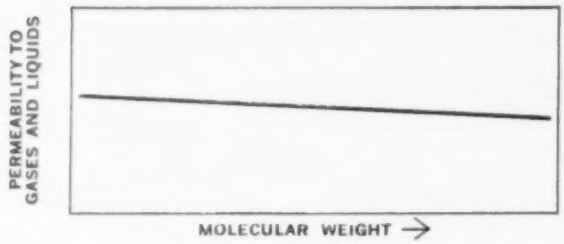
HOW MOLECULAR WEIGHT AFFECTS POLYETHYLENE PROPERTIES

Molecular weight is one of the three most important resin characteristics that determine end-use properties of polyethylene. *Density* and *molecular weight distribution* are two others.

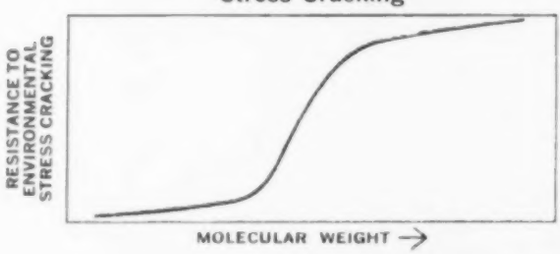
Melt Index is an approximate measure of molecular weight. Resins with low molecular weight have high melt index values, and vice versa.

The following graphs show the effect of increasing molecular weight, (or decreasing melt index) assuming that density and molecular weight distribution remain constant. In practice, of course, these characteristics are different for different resins so the effects of all three must be considered.

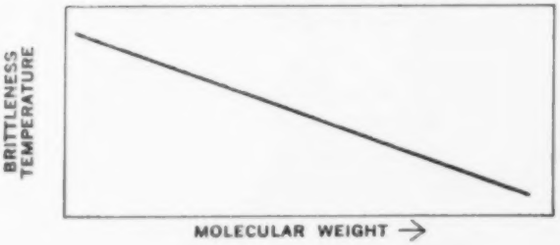
Permeability



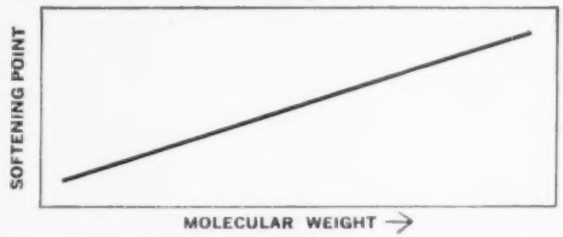
Resistance to Environmental Stress Cracking



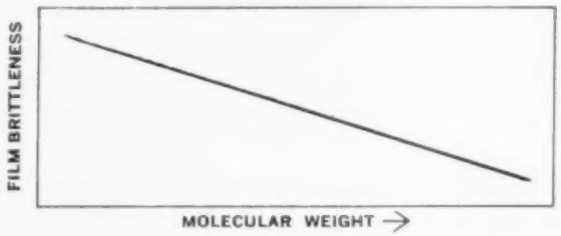
Low Temperature Brittleness



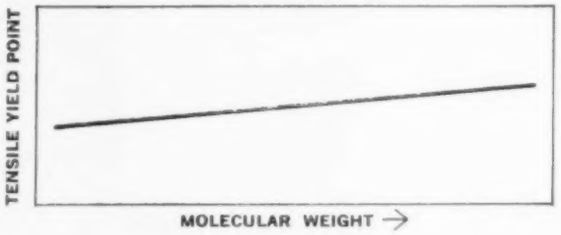
Softening Point



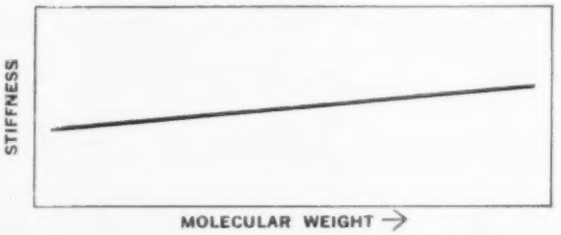
Film Brittleness



Tensile Yield Point



Stiffness



U.S.I. "tailors" PETROTHENE® polyethylene resins to specific end uses by controlling the molecular characteristics that determine these properties. Result: a family of resins from which a fabricator can choose the specific material best suited to his processing conditions, and product requirements.

If you have a specific problem that might be solved by one of the new resins, one of U.S.I.'s technical service engineers will be glad to work with you to find the solution.

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SPE JOURNAL

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Process pipes and distillation tower of a section of Celanese Corporation of America's new polyolefin resin plant which went on stream in February.

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Fig.

THE MARK OF QUALITY

BARBER COLMAN

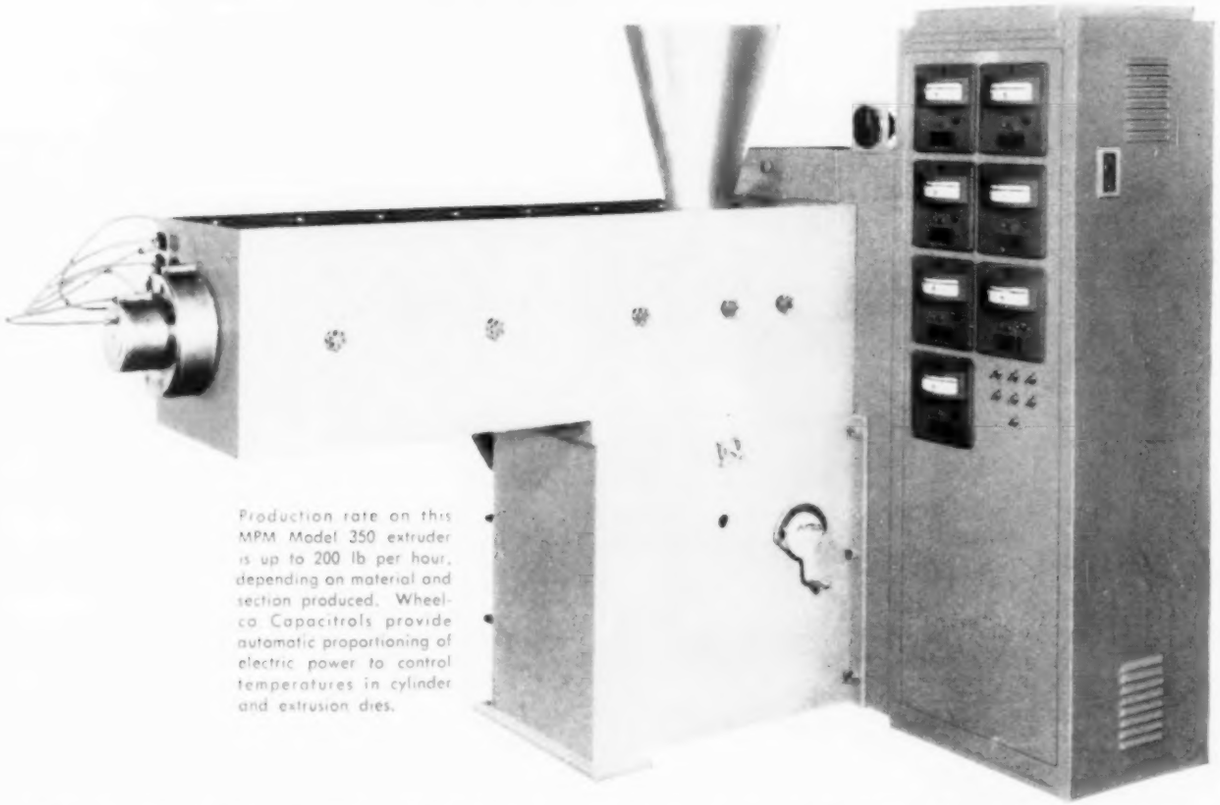
Wheelco Instruments

Precise temperature control on versatile thermoplastic extruder depends on Wheelco Instruments

When it comes to high production of plastic items, such as tubular or flat film for bags and packaging, wire insulation, garden hose, rods, strip, shapes, etc. — that's where this unit, built by Modern Plastic Machinery Corp., Lodi, New Jersey, more than holds its own. It combines high production with versatility, making it doubly valuable to plastics extruders of all sizes.

When it comes to precise temperature control in every step of the forming process, that's where you find Wheelco Capacitrols doing an equally outstanding job. Precision and versatility are just as important in the control instruments used as in other vital components of the MPM extruder. That's why you find Wheelco Instruments preferred and specified by a wide margin over all other makes combined throughout the plastics industry.

Wheelco Capacitrols are designed and built to give outstanding day-in-day-out performance with minimum downtime. Where inspection or maintenance is required, Wheelco plug-in construction makes either job easier and faster. Write today for your copy of Bulletin F-6485, "Capacitrols for the Plastics Industry"!



Production rate on this MPM Model 350 extruder is up to 200 lb per hour, depending on material and section produced. Wheelco Capacitrols provide automatic proportioning of electric power to control temperatures in cylinder and extrusion dies.

BARBER-COLMAN COMPANY

Dept. Q, 1575 Rock Street, Rockford, Illinois, U.S.A.

BARBER-COLMAN of CANADA, Ltd., Dept. Q, Toronto and Montreal, Canada

STYRENES

Better than ever, and more of them

Styrenes are being used for so many different products because their increased variety offers so wide a range in choice of properties.

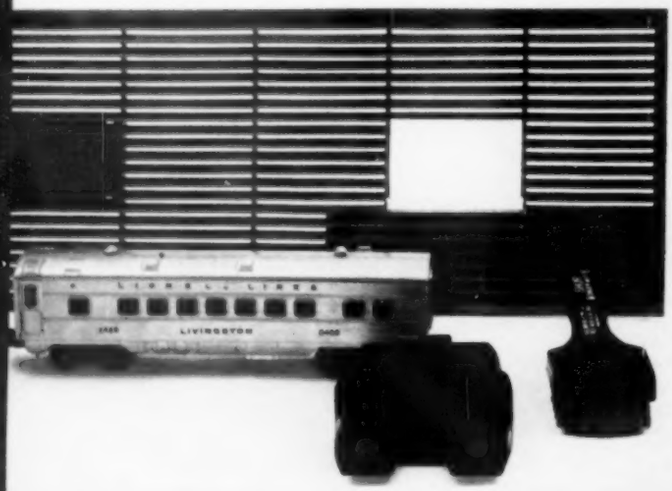
Your own products may profit from a quick review of the different styrene molding materials offered by Bakelite Company. They are described on the following pages.

(Continued on next page)

For Chemical Resistance RMD-4511

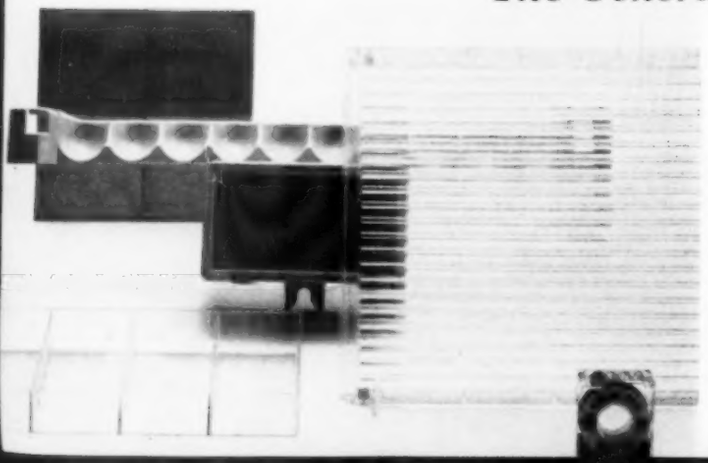
This acrylonitrile-styrene copolymer, known as C-11 plastic, is particularly outstanding in chemical resistance and strength properties. It is especially desirable for molded articles where crazing may be a problem. Articles molded from RMD-4511 are resistant to most of the chemicals common to households; detergents, foods, and cleaners which attack the surfaces of many plastics. This combination of properties makes RMD-4511 ideal for molded housewares, packages, and appliance parts. Its utility is enhanced by a full range of available colors.

For Impact Resistance TMD-5151



This rubber-modified polystyrene combines high impact strength and good molding properties. It is available in a wide range of bright opaque colors. TMD-5151 has a low bulk factor, flows freely, and sets up quickly. Articles molded from TMD-5151 demonstrate good electrical properties, superior mechanical strength, and excellent appearance. The Izod impact strength of this material is as much as five times that of general-purpose polystyrene.

The General-Purpose Styrene SMD-3500



Free-flowing SMD-3500 is a general-purpose compound that combines excellent moldability and fast setup. It is available in a crystal clear formulation or in a wide range of brilliant colors. This material has a low bulk factor and good electrical, mechanical, and optical properties. SMD-3500 is widely used for injection molding operations requiring superior ease of molding.

For applications such as packaging where extra-high flow is desired, *SMD-3700* is recommended for best performance on fast cycles.

TYPICAL PROPERTIES	RDM-4511 (formerly BMC-11) Acrylonitrile-Styrene Copolymer	TMD-5161 Impact- and Heat-Resistant	SMD-3500 General-Purpose Polystyrene	TMD-2155 Extra-High-Impact Polystyrene	TDM-5151 High-Impact Polystyrene
Values Relating to Fabrication					
Specific Gravity (D792-50) (Varies slightly with color)	1.07	1.04	1.05	1.03	1.04
Weight per Cubic Inch (Molded) gms.	17.5	17.0	17.2	16.9	17.0
Bulk Factor (D1182-54) Diced	1.98	—	1.98		
Pellet	1.71	1.72	1.71	1.71	1.71
Molding Shrinkage (D955-51), in./in.	0.004	0.004	0.005	0.005	0.005
Values from Electrical Tests					
Dielectric Strength (D149-55T) Short time, volts/mil	420	460	640	515	460
Dissipation Factor (D150-54T) At 60 c., 1 kc., 1 mc.	.007	.002	.0002	.001	.001
Dielectric Constant (D150-54T) At 60 c., 1 kc., 1 mc.	2.75	2.60	2.45	2.50	2.60
Volume Resistivity (D257-54T) ohm-cms.	$>10^{14}$	$>10^{14}$	$>10^{14}$	$>10^{14}$	$>10^{14}$
Values from Mechanical Tests					
Izod Impact Strength (D256-54T) ft-lb/in. of notch					
1/8 in. thick	0.55	2.6	0.47	8.0	2.3
1/4 in. thick	0.45	1.1	0.33	3.6	1.0
Tensile Strength (D638-52T), psi	12,000	6,700	7200	4300	4000
Elongation in Tension (D638-52T), per cent	3.2	5	2	25	28
Flexural Strength (D790-49T), psi	17,300	9,200	9500	No failure	No failure
Modulus of Elasticity in Flexure (D790-49T), psi	5.2×10^5	3.9×10^5	4.5×10^5	2.75×10^5	3.7×10^5
Values from Miscellaneous Tests					
Heat Distortion Temp. (D648-45T) (264 psi) deg. F.					
1/8 in. thick		189			
1/4 in. thick	200	192	183	184	173
1/2 in. thick		198			
Thermal Coefficient of Linear Expansion (D696-44) per deg. C.	7×10^{-5}	7.5×10^{-5}	7×10^{-5}	7.5×10^{-5}	7.5×10^{-5}
Water Absorption (D570-54T), per cent gain in weight in 24 hours	0.23	0.140	.04	0.14	0.10
Rockwell Hardness (D785-51)	M83	L78	M67	L25	L71

For Impact and Heat Resistance TMD-5161

A new compound, TMD-5161 is a rubber-modified material that combines these two important characteristics. Rugged tests have proven its superior mechanical strength, high resistance to heat distortion, and good electrical properties. It comes in an almost unlimited range of opaque colors. Finished moldings have a rich, high gloss. TMD-5161 assures intricate injection molded pieces produced on fast cycles with higher economy. Suggested applications include radio cabinets, photographic equipment, electric fan housings, vacuum cleaner parts, and air conditioner grilles.

SOMETHING NEW!

Ask about the new, medium-impact styrene material *SMD-5020*, for extra-duty applications such as closures.

For further information on any or all of these materials or assistance in applying them to your products, write Dept. XE-171.

For Extra-High-Impact Resistance TMD-2155

Even at temperatures of −25 deg. C., this rubber-modified polystyrene possesses extra-high-impact strength. Compared to the general-purpose styrenes, it has an Izod impact strength approximately eighteen times as great. TMD-2155 is supplied in a variety of bright opaque colors. It retains the excellent molding characteristics for which styrenes are noted—ease of flow at molding temperature, fast cycles, good mold release, and a minimum of strain and weld lines. In addition, it exhibits a high heat distortion point, together with superior surface gloss and excellent color.

BAKELITE BRAND PLASTICS

BAKELITE COMPANY, *Division of Union Carbide Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC.

In Canada: Bakelite Company Canada Limited, Belleville, Ontario

Ideal for handles, grips—the brilliant, lustrous surface finish of Forticel, combined with low thermal conductivity, provide touch comfort. Tough, easily molded over metal inserts, providing excellent retention of metal cores—Forticel adds beauty, precision, longer service life. Molded by A. G. P. Corporation, Peru, Indiana.

PROPERTIES THAT MAKE FORTICEL A MORE DESIRABLE PLASTIC

Flow temperature: (°C.) (A.S.T.M.)	D569-48	167—178
Specific gravity	D176-42T	1.18—1.21
Tensile properties:		
Yield (p.s.i.)	D638-52T	3380—5020
Break (p.s.i.)	D638-52T	3470—5240
Elongation (%)	D638-52T	56—66
Flexural properties:		
Flexural strength (p.s.i. at break)	D790-49T	6400—8500
Flexural modulus (10^6 p.s.i.)	D790-49T	0.23—0.30
Rockwell hardness: (R scale)	D785-51	62—94
Izod impact: (ft. lb./in. notch)	D256-43T	•2.7—11.0
Heat distortion: (°C.)	D648-45T	59—70
Water absorption:		
% sol. lost	D570-42	0.00—0.08
% moisture gain	D570-42	1.5—1.8
% water absorption	D570-42	1.6—1.8

BISSELL *selects* FORTICEL

new Celanese propionate thermoplastic to handle its new "Continental" sweeper

The Bissell Carpet Sweeper Co. joins other famous name manufacturers like Zenith and America's leading pen manufacturers in the selection of Forticel for its unique balance of properties – properties that can be counted on to improve finished products – properties that can speed production, cut finishing operations.

Forticel offers the designer and manufacturer the toughness and high speed moldability of the cellulosics. But Forticel offers the big plus combination of: *better dimensional stability, excellent form retention, freedom from unpleasant odor.* Forticel's combined qualities of moldability with superb surface finish, high impact strength with form retention, meet the demands of applications that need *something more* in a thermoplastic molding material.

It's no wonder that within months of its introduction, Forticel established a reputation from top management to the man on the production line, a reputation not only as a designers' and molders' plastic, but as a better production material around which plans can be built and products improved.

If you haven't already evaluated Forticel, we urge you to do so. You will then understand why Forticel, one of the most carefully engineered thermoplastics in use today, is being written into an increasing number of specifications. Celanese Corporation of America, Plastics Division, Newark 5, N. J. Canadian affiliate: Canadian Chemical Co., Limited, Montreal, Toronto and Vancouver.

Celanese
plastics

Celanese® Forticel®

Celanese Corporation of America, Plastics Division
Dept. 170-E, 290 Ferry Street, Newark 5, N. J.

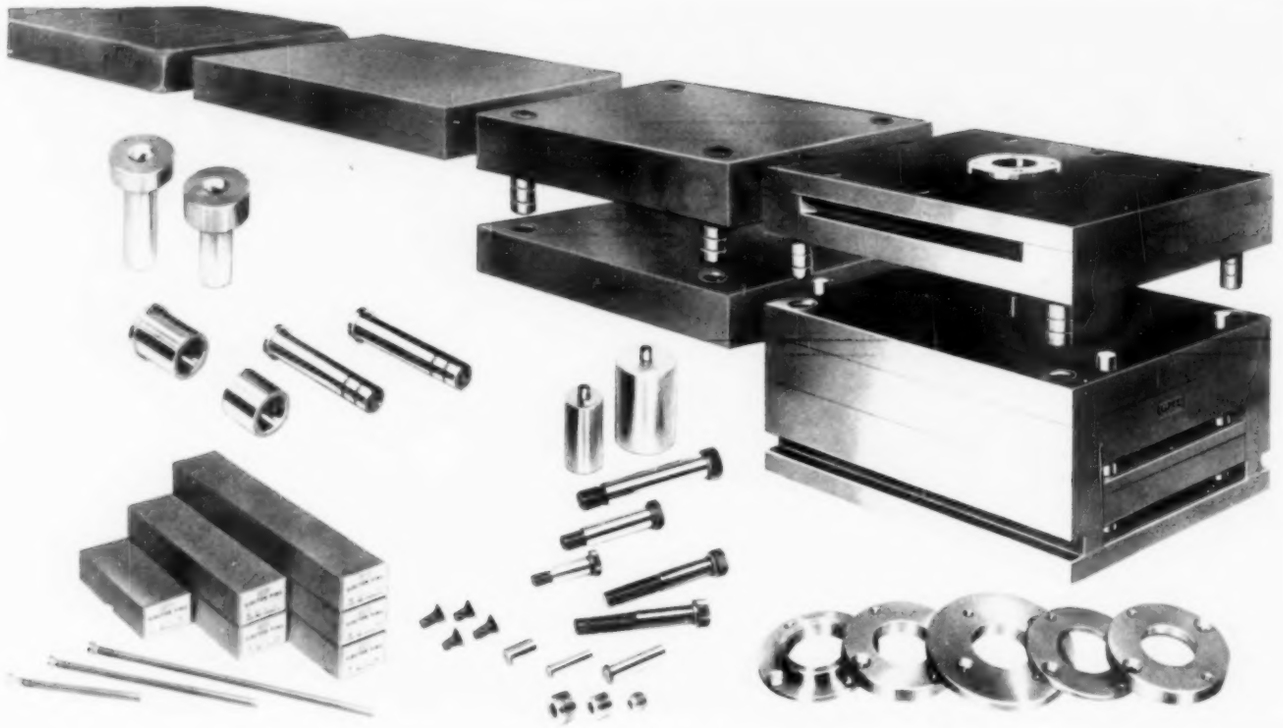
Please send me New Product Bulletin NP-16 on Forticel Plastic.

Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____



PROGRESS THROUGH STANDARDS

. . . and how DME "helped"

The history of economy in modern business has been directly related to the history of Standardization. One of the major elements affecting the economic production of finished plastic parts is the high initial cost of the mold. A progressive step in reducing mold cost, without sacrificing the high quality required, has been successfully achieved through Standardization.

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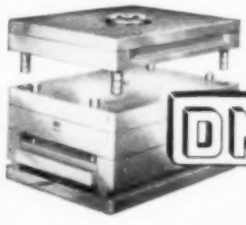

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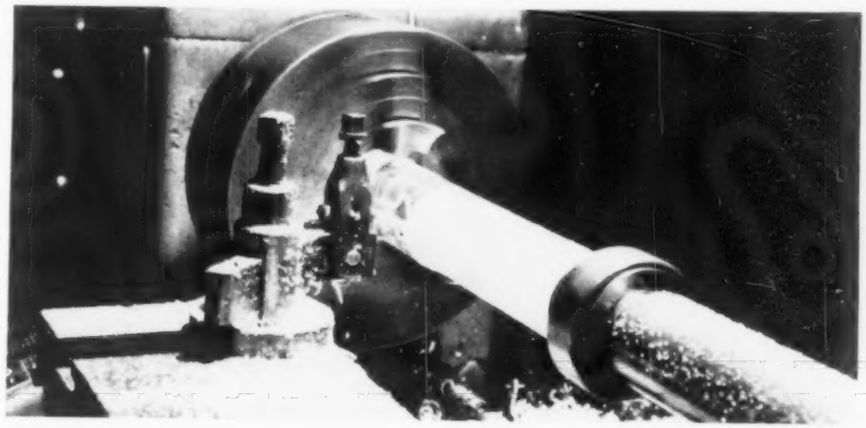

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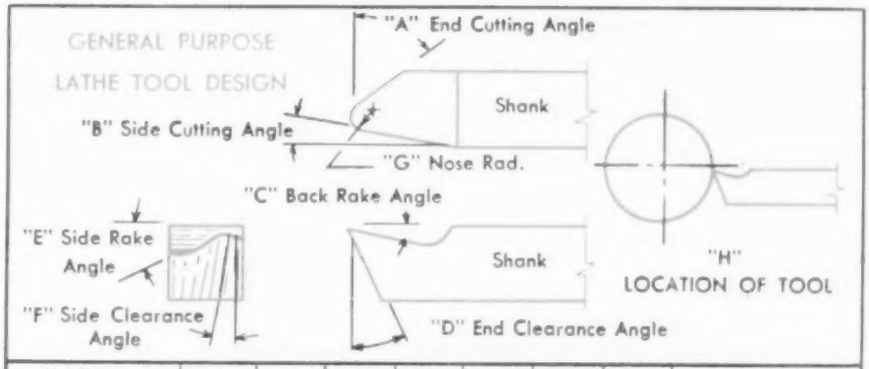

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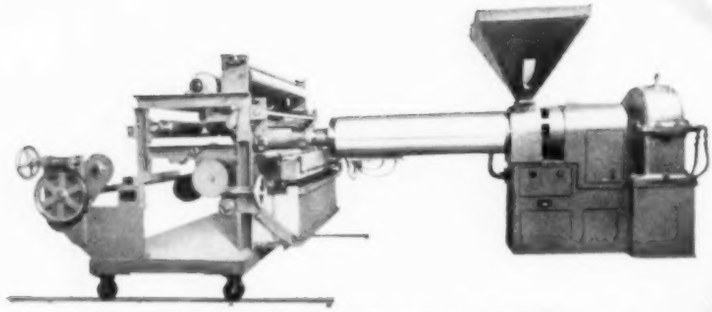

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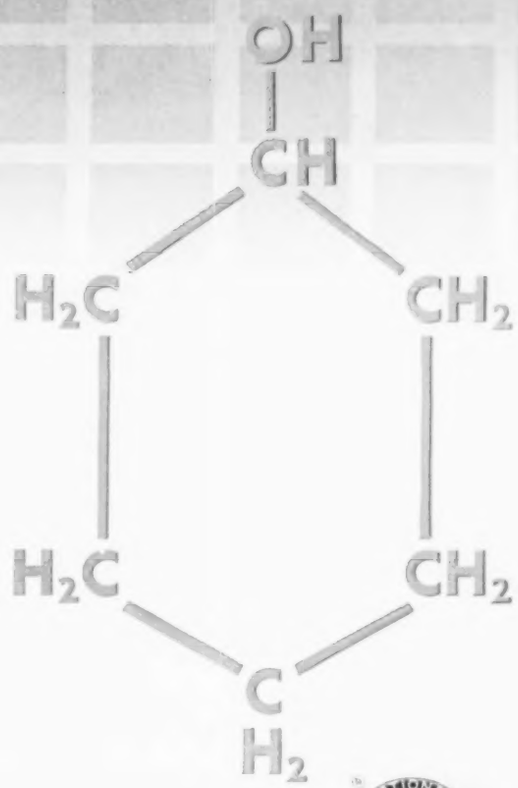

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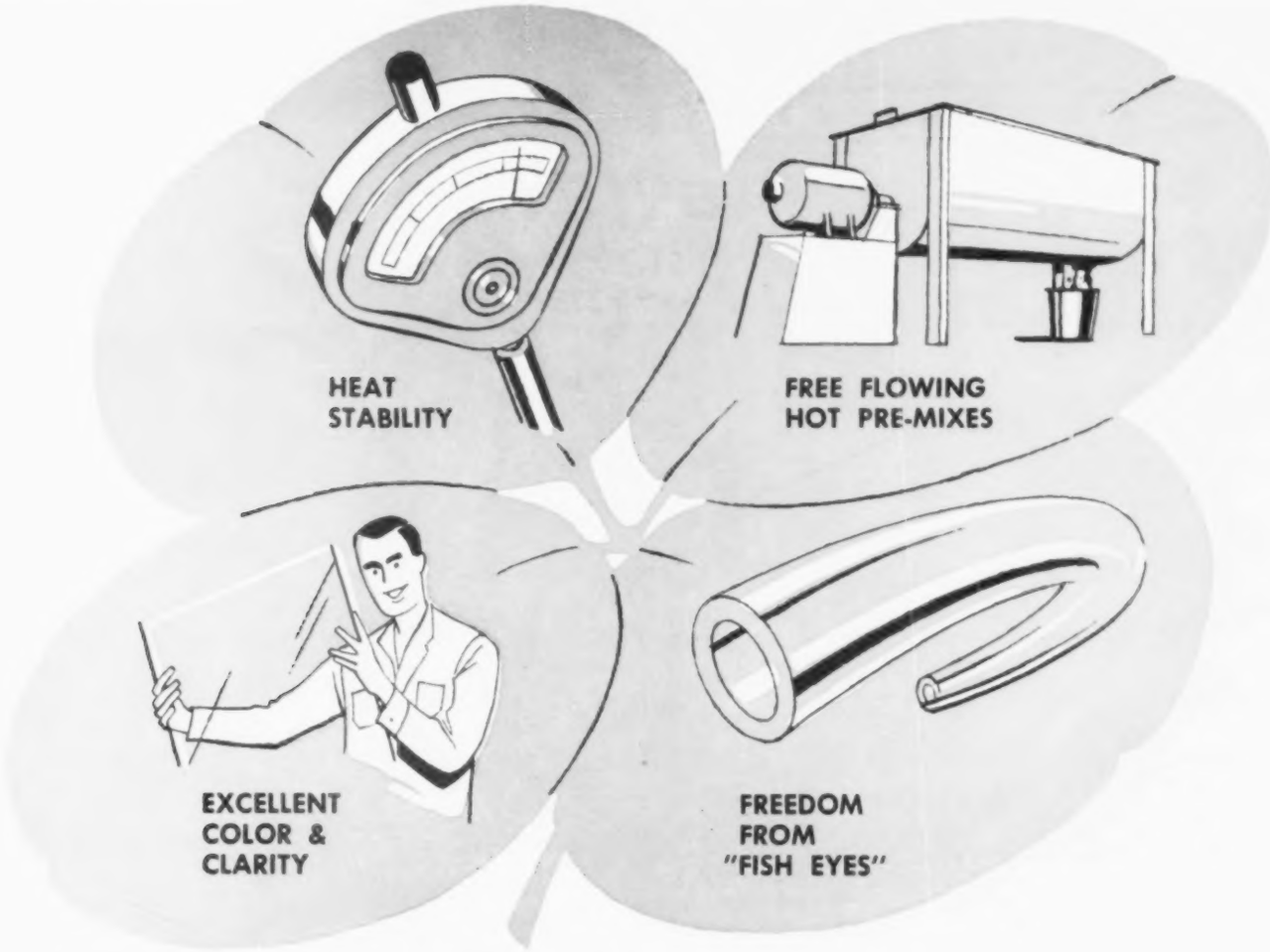

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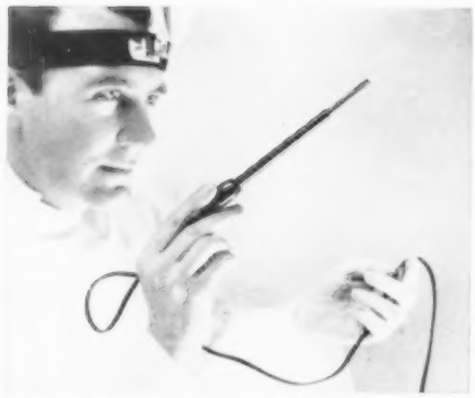

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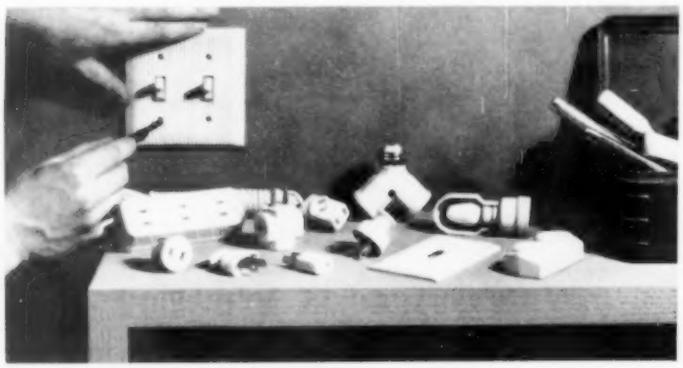

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A New Concept for . . .

Molding Small Parts

John L. Hull

Hull-Standard Corp.
Abington, Pennsylvania

. . . transfer molding of miniature parts using phenolic or alkyd can be a short cut to production efficiency . . .

FOR almost a decade the molding industry has been hearing reports of a fascinating little molding machine in the mid-west—a fully automatic transfer molding press for thermosetting plastics—which is ideal for molding small parts for miniature and sub-miniature electronic components. Today the commercially available unit is a reality. Our purpose is to discuss the press, its area of application and its advantages as well as its limitations.

This new tool is a fully automatic transfer molding press designed specifically for molding small and miniature component parts in quantities from a few hundred to several hundred thousand. The press incorporates new concepts in design and phenomenally low tooling costs. The press has proven ideal for (1) full-scale production of small parts (2) inexpensive development and testing of new parts (3) testing of molding compounds, and (4) product sales and market research.

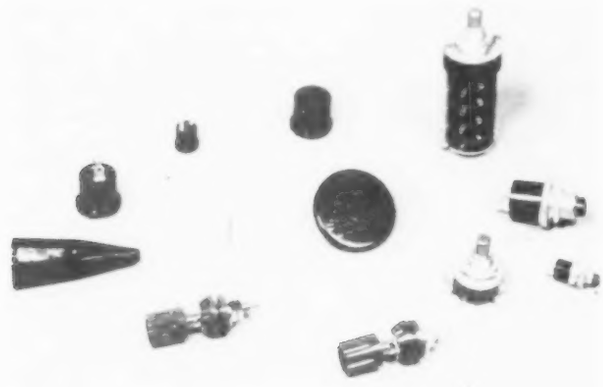

Figure 1. Typical miniature molded parts

Figure 2. Photographed on a larger scale, here are molded parts that go to make up the components in Figure 1.

What do we mean by "small" parts?

Typical of the miniature and sub-miniature components to be discussed are those shown in Figure 1. These are components used in radio and communications equipment, ordnance, industrial instruments, computers and all fields where the trend is toward smaller lighter products.

Figure 2 shows a random sampling of molded parts which go to make up such components. The maximum dimensions of these parts do not exceed 1-¾" x 1-¼" x ⅞" deep, which are the largest size parts which can be produced in a two-cavity mold. Smaller pieces can be made in molds of four or six cavities. This size limitation is due partly to the construction of the press and partly to the standard mold blocks used. You will note that none of the parts has inserts. Automatic insert loading is a problem, and this press does not solve that problem. As compared to semi-automatic molding with inserts, it has in a number of instances proven more economical to gain the advantages of automatic molding without inserts, and then to put inserts in as a secondary operation. This procedure may necessitate some redesign of a given part. Experience indicates that the pieces shown are feasible on this small press when the production requirements are about 8,000 parts per week or less; i.e., less than half a million per year. This is the quantity we could conservatively expect to produce in a two-cavity mold running 20 hours a day, 6 days a week. Where larger quantities of small parts are required, it is generally better to use conventional molding presses of the larger size, bearing in mind the capital investment required for the larger presses and for the larger molds.

This paper was presented at the SPE Thirteenth Annual Technical Conference.

Why automatic transfer molding?

The variety of pieces shown in illustration 1 and 2 reveal indirectly some of the advantages of an automatic **transfer** molding machine. Note that some pieces have through holes. The tolerances on some pieces have been held to ±0.0005". On some you will note fine holes indicating very delicate core pins. Such core pins might break off in compression molding, but are possible in transfer molding. Additionally, transfer molded parts generally require less finishing costs since flash is held to a bare minimum. The over-all cycle for molding practically any of these parts can be conservatively estimated at 2 minutes. Of especial note is the mold cost. For any of these small parts, the tool room hours to construct the entire mold—2 cavities for the larger pieces, as many as 8 cavities for some of the smaller pieces shown—came to no more than 105 hours. One 6 cavity mold required only 58 hours, while another required only 64 hours. At a figure of $6.00 or $7.00 per hour, plus a few dollars for material, the mold costs on the parts shown are all below $1,000.00.

Wide range of materials

Following are listed several molding compounds which have proven highly satisfactory in operation on this press:

Phenolic G. P. Durez 11540
Phenolic, Mica filled, Durez 16274
Phenolic, Mica filled, Bakelite 17748
Phenolic, G. P. Bakelite BMG 2010
Diallyl Phthalate, Acme 1-501
Melamine, cellulose filled, Plaskon MS 0245
Phenolic, Mica filled, Bakelite 17080
Phenolic Ammonia Free, Durez 15528
Alkyd, Plaskon 422

The list is by no means complete but serves to indicate the range of compounds which the press will handle. These are loaded into the press hopper as cold powders of no special granulation. The flow or plasticity of most of these materials is 12. This is a rather soft material and partly accounts for the somewhat long cure time. Using this soft flow material enables successful molding without damage to even the finest core pin. As in most automatic presses, any restriction in compound usage is usually not whether the material will mold, but rather whether the material lends itself to automatic feeding. If the bulk factor is in excess of three, the molder generally has to experiment with a sample of the compound to determine the feasibility of molding it.

The Molding Press

Figure 3. (Left) Commercial model of the small-parts press, and (right) an experimental model.

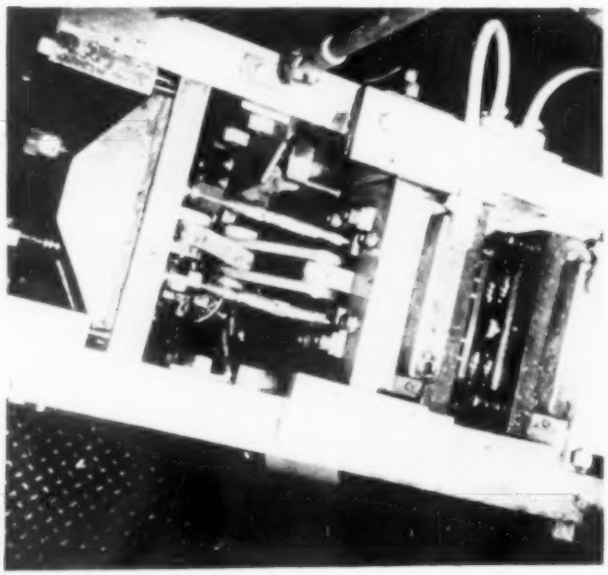

Figure 4. Close-up of mold area.

The new tool

What is this new tool and what makes it ideal for molding the parts shown? On the right in Figure 3 is one of the experimental models on which practically all the development work was carried out over a period of more than eight years up to the present time. Nine presses similar to this experimental model are in active production use at Grayhill Co., LaGrange, Illinois, economically molding parts both for proprietary items and for custom work. On the left side is basically the same press, shown as it is now available to the trade. The essential operating characteristics and components are the same in each unit. This is a horizontal press, air-operated, arranged for readily available shop air pressure of 80 p.s.i. Being horizontal, the press utilizes gravity for part of the ejection. Since the press is horizontal, the material must be loaded after the mold is closed. It cannot, therefore, be used for compression molding. (This fact is mentioned, because we are frequently asked if the press will do compression molding.)

Molding compounds are placed in the hopper standing above the press at the center. They are metered into the horizontal transfer cylinder and advanced to the mold area by the transfer plunger. At the conclusion of the cure cycle, the molded parts are positively ejected from the mold area. Electric and pneumatic controls, with complete safety interlock, enable simple adjustment of clamp pressure to about 15 tons, transfer ram pressure to about 9,000 p.s.i. hydrostatic pressure, and cure time from 0 to 4 minutes. Charge is readily adjustable volumetrically from zero to about 1.5 cu. in., or up to approximately 15 grams, depending of course on bulk factor of the molding compound. A selector switch readily converts the press from automatic to manual operation for set-up and mold break-in operation.

Figure 4 presents a close-up of the mold area, in this particular case shown on the experimental model. This view is of the transfer side of the mold block. The transfer ram normally protrudes slightly beyond the parting face of the mold at the end of each cycle. Faintly visible is the end of the transfer of cylinder which is arranged flush with the face of the mold.

Figure 5 shows the other side of the mold area, this time on the production model. The mold measures about 2 inches x 5 inches projected area. It is held in place by retainer sets which are a part of the press rather than a part of the mold. Behind the retainer sets are the heating platens and the leads supplying electric current to the heating cartridges. The hole at the end of the cover on each heating platen is for adjustment of thermo-switches to independently control the temperature over a wide range. The runners are machined in this knock-out side. The knock-out pins are shown protruding from the face of the mold. When the press opens on completion of the cure, the molded pieces as well as the cull and runners are made to follow this half of the mold. Just prior to the end of the opening stroke, the knock-out pins push the molded part away from the mold and the stripper fingers remove the complete piece from the knock-out pins. The piece then falls down between the mold blocks into a checking device. If all of the molded parts have been ejected, the press automatically proceeds to the next cycle.

Why the "phenomenally" low mold cost?

As mentioned earlier, new concepts in molding lead to amazingly low mold costs. Many features normally a part of conventional molds have been made an integral part of the press. New molds, therefore, consist of the required cavity inserts arranged in standard mold blocks. Figures 4 and 5 show the arrangement of mold frames or retainer sets, heating platens, heating cartridges, and temperature controllers, which are part of the basic press, as are also the major elements of the ejection and stripping system. The transfer cylinder and loading mechanism are also part of the press, and are completely adjustable to varying mold thickness without additional tooling cost.

Figure 6 shows schematically the mold arrangement, while Figure 7 shows a typical mold set with sample part. Often a mold can be designed, constructed, and in production within one week. Mold changeovers, obviously, are simple and inexpensive. In this particular mold runners are on the knockout side, gates on the transfer side —their size depending on part design and weight. In multi-cavity molds, users recommend individual runners for each cavity. Vents are about 0.0015" by 0.100".

In at least one instance, when Grayhill received an invitation to bid on a molded part, they constructed a mold, produced some sample parts which they submitted with their quotation—and all this before any competitor had quoted. This procedure is not standard, but illustrates what can be done if all possible short-cuts are taken to expedite a given job.

Figure 8 shows several clusters of molded parts exactly as they come from the press. The amount of materials in the runners and cull is of course wastage, but amounts generally to no more than 1.5 mils per cycle. Users report that in a two-cavity mold, the cost of molding compound used is normally less than 12 percent of the finished part cost.

Following are several selected case histories which may lead you to think how this unit might serve to lower production costs, or to improve product quality, or to enable you to create new products. (For, after all, a new tool isn't really needed unless it can do certain jobs better, or new jobs which otherwise cannot be done). In some of these applications, the savings were in the actual molded part. But in others the saving became apparent in the overall picture. *Designers must go deeper than mere substitution to derive full benefit from this new tool.*

A better product at lower overall costs

The case history presented in Figure 9 illustrates how intelligent application of the machine produced a better miniature switch and at the same time lowered assembly costs and inventory costs. In this case, the low mold cost, plus the ability of the press to mold thickness to tolerance as well as through-holes, make the successful application possible.

Under study is a rotary tap switch. In application, this miniature switch is turned to one or more contact positions by means of a knob affixed to the shaft. The corrugated springs visible in the cross section drawing are needed to supply sufficient pressure to maintain good contact and a high detent, yet the springs must not be so stiff as to cause binding. The correct force on the switch rotor is of vital importance to consistent performance of the switch.

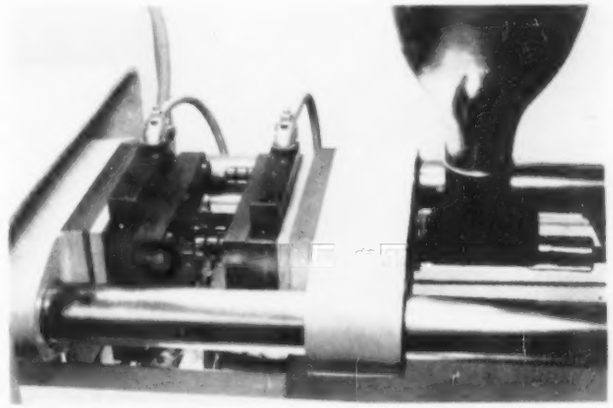

Figure 5. Close shot of mold area on production model.

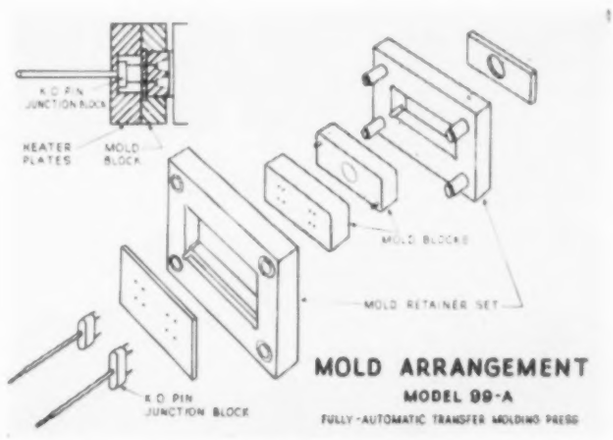

Figure 6. Exploded view of mold arrangement.

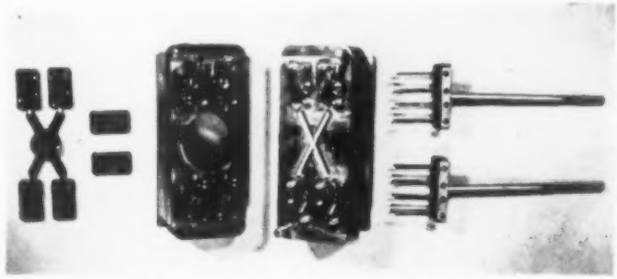

Figure 7. Molded parts as they come from the mold.

As is readily recognized, variations in thickness of all components in the assembly affect the spring compression. In the early production runs on this particular switch, the washer shaded in the cross section was made of two parts stamped from nylon laminate stock. This rather expensive grade of laminate was selected primarily because of its lower moisture absorption properties. It was further necessary to wax-impregnate the laminate as additional protection against trapped moisture. The commercial tolerance of 0.050" thick material used for one part is ± 0.005",

Figure 8. Molded switch parts

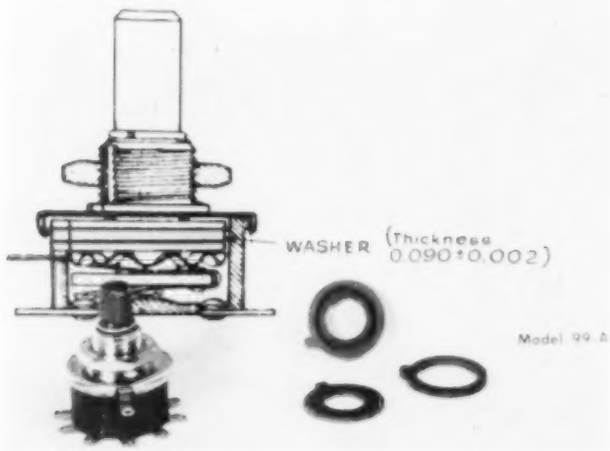

Figure 9. Plan and result of design for a rotary switch

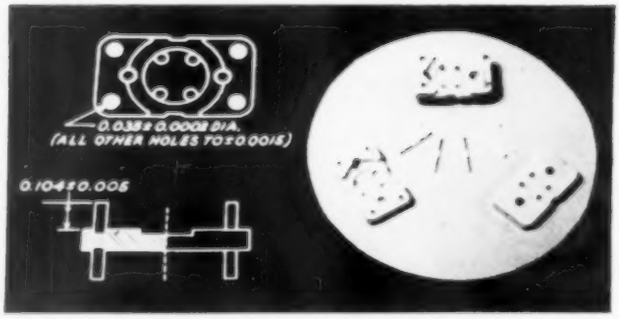

Figure 10. Plan for a molded terminal board.

while the commercial tolerance of 0.032" thick material used for the other is ± 0.0035". In addition, the wax impregnating caused further thickness variations. The tolerance accumulation for just these two parts was therefore something more than ± 0.0085", or about ± 10 percent. The molded washer, designed to replace the laminated parts, is readily produced on the small press with an overall thickness tolerance of ± 0.002".

The cost comparison of these two approaches to production is significant. Previously the two laminated parts were costing a total of $7.06 per thousand, including the wax impregnation. The present molded part costs $10.21 per thousand, or almost 50 percent more. This additional cost, however, is offset several times by the fact that now the assembled switches give consistent performance, rejects are minimized, the molded phenolic is a better insulator, and lower assembly costs result from the handling and stocking of only one part as compared to two. With the use of a molded part, furthermore, it became possible to choose an overall thickness which was believed to be the optimum for the assembly, as the molder was no longer tied down to the commercially available sizes of laminated stock.

Hole tolerances of 0.0002", automatically!

This next application required exceptionally close tolerances for successful production of a walkie-talkie one-fourth the size of that used in World War II. It is a good example of close cooperation between molder and customer in getting full benefit from a versatile tool. It is not speculation, incidentally, to note that such miniaturization of the walkie-talkie and of other military and commercial items indicates a growing need for presses of this type.

Figure 10 presents for review a molded terminal board. The molded part drawing shows that a tolerance of 0.0002" is being held on the diameter of the four holes into which the terminal pins are later inserted. To hold such a close tolerance, it is necessary to change the core pins frequently, but this is a relatively simple operation inasmuch as the mold construction is simple and the mold changeover costs are very low. With larger press equipment, such frequent pin changes could become prohibitive in cost. The terminal board is molded of a mica-filled phenolic material primarily because of its low electrical loss characteristics when employed in very high frequency circuits. The "cost" for constructing a 6-cavity mold for producing this part is approximately 100 hours of tool room labor.

In application, leads are soldered to the gold-plated terminal pins as close to the terminal board as possible. It is not at all inconceivable that the part could be made with the pins molded in place instead of inserted as a secondary operation. This procedure would introduce the problem of flash around the projecting part of the pin. Any method of removing such flash would doubtless remove some gold plating as well. A more practical solution to the problem would be to insert the terminal pins as a secondary operation and thereby preserve completely the plating and the solderability of the terminals. This also proved to be less expensive in the overall picture because the molded part could be made on completely automatic equipment and the terminals assembled in a semi-automatic secondary-operation machine. In assembly, the terminal board is heated before inserting the pins. This heating is a factor in obtaining a tighter press fit of the terminals without experiencing cracking of the molded board. The ability of this molding press to produce close toleranced holes, coupled with a fully automatic operation, leads to the success of this particular part.

Figure 11. Test clips could be made on speculation because of low mold cost.

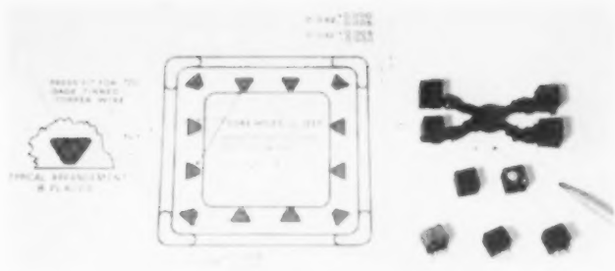

Figure 12. Fragile sections and delicate core pins in this part require transfer molding for automatic production.

A gamble to test market pays off

This next example shows dramatically how the press can be used in research and development of new products. The test clip shown in Figure 11 is a new and unique design, built on speculation. The low mold cost of the press enabled samples to be made and placed on the market in very short time and at relatively low cost. Sales of the test clip have grown steadily since its introduction.

The design of the test clip is unique in that the conducting parts cannot short circuit if two test clips should touch one another. It is ideal for electrical trouble shooting on panels with terminals close together, such as telephone switchboard panels. The cost of this type test clip would, of course, be higher than the cost of conventional test clips, and the molder had no sure way of evaluating the potential market for the item. Since these particular parts are difficult from a mold construction standpoint, the molds to produce the two parts required a total of approximately 240 tool room hours. Considering that the other parts used in the final assembly are relatively insignificant in terms of cost, it is obvious that the investment in molds was the real gamble. Without the small press being available, it could have cost many times that investment in order to produce sufficient actual parts with which to sample the market.

It is significant to note that the same original molds are today still supplying the production needs because they were not temporary tools in the usual sense of the molding trade, but rather low cost molds made possible by the design features of this molding press. For many molded parts, it is possible to make very low cost molds, single or double cavity. And it is also possible to make sample cavities which are basically cavity inserts and which can be placed into a standard mold block arranged to accept such sample cavities. With this arrangement, therefore, we have an "insert-insert" type mold.

No other way to mold automatically

Figure 12 shows a molded part that can be made automatically only on a transfer press, because of the fragile sections and the delicate core pins. The component part shown is used in computer equipment manufactured by the Burroughs Corporation. In this instance the part is molded by Milton Ross Metals of Davisville, Pa. The component part houses a coil with the winding tapped at several points and soldered to the terminals shown. The winding itself is cast in epoxy after assembly. The component part is then plugged into a socket similar to a radio tube socket.

The original design of this component part, as shown at the left of the group of three, called for punched phenolic sheet into which were pressed the terminal pins. After soldering the leads from the winding to the pins, the unit was cast in epoxy resin. Cost figures are not available on this original type, but handling of the resin, as well as the number of persons required for potting only 200 per day, made the figures very high. The present design involves a molded housing which supports the terminal pins as well as the coil and the epoxy resin. In assembly, the terminal pins are inserted part way, then soldered to the leads from the winding, and then the terminals are pushed in against a shoulder such that the soldered connections are below the edge of the molded part. Epoxy resin is then poured directly into the molded block and allowed to set up. Production quantities now are over 1000 per day, with the same number of assembly girls. The savings in this new approach come from eliminating the punched phenolic sheet and eliminating the extra pots into which the epoxy used to be cast.

In early production with this new design, a two-cavity mold was used in a conventional semi-automatic transfer press. Rejects were excessive. The part is now produced in a 4-cavity family type mold, and two pieces of each size are produced. The automatic operation now permits almost twice as many heats per shift as did the former semi-automatic operation, with very low percentage of rejects. Note the slenderness ratio of the 0.030" diameter core pins used, almost 7 to 1. Note the thin wall section around each hole. The holes were designed triangular to add strength to the core pins, but the inserted terminal pins are, of course, round.

This particular item is another good example of how costs can be lowered and products improved by the designer who takes full advantage of available molding machines and methods. Although this part, as well as some of the others shown, can of course be molded semi-automatically on conventional transfer presses, the lower mold costs, and the automatic production, as well as Burroughs' quantity requirements for this particular component, have made the small automatic press ideal. It goes without saying that producing this part by automatic compression molding techniques is impossible because of the fragile core pins.

Ideal as lab press

Although the unit has been designed and constructed primarily as a production press, it has proven exceptionally useful as a laboratory press. The simple mold arrangement permits rapid and inexpensive programs for new parts development and testing. And since the press is automatic, eliminating many human variables in test-sample production, each sample part is identical to the previous one—assuring consistent test results from sample to sample.

When extremely close tolerances are required on a production item, development molds are tested and perfected to determine exactly the part shrinkage which will

(Please turn to Page 60)

Pre-Impregnated Reinforcements For Epoxy Laminates

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. . . dry layup of pre-impregnated reinforcement-epoxy offers many advantages. Handling and curing techniques, and properties of finished products are described . . .

WHAT STRUCTURAL characteristics does industry request from fabricators of plastic laminates derived from preimpregnated reinforcements? Essentially, these are considered to be as follows:

1. High mechanical strengths, both static and dynamic, coupled with a favorable strength to weight ratio.
2. Strength retention on exposure to temperature, chemicals, and weather.
3. Good electrical properties.

Superior grades of structural and electrical laminates, offering these characteristics, are available today through the use of epoxy resin, "B-staged" on glass fabrics.

Although it has become almost conventional to speak of the unique merits of these new resins as compared with standard thermosetting plastics, it is still profitable to review the advantages which are making them the principal contender for reinforced plastic applications.

In addition to their excellent mechanical and electrical properties, epoxy resins exhibit the following outstanding characteristics:

1. Remarkable adhesive qualities that contribute to the high bond strength of laminates with this material.
2. A great degree of surface activity in the liquid state that provides unusually good wetting of reinforcing material.
3. Low volume shrinkage, due to the highly associated nature of the liquid resin, holds strain to minimum during cure.
4. Exceptional resistance to heat, water, and corrosive agents.
5. Compatibility with commonly used preimpregnating techniques.

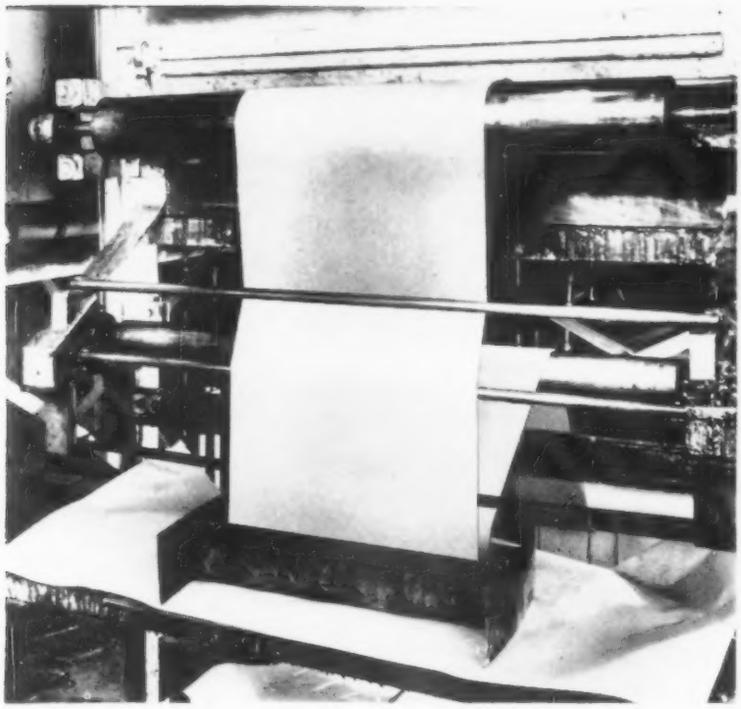
These advantages of epoxies have recommended them highly for laminates using the dry lay-up method. Dry, dust-free, easily handled, ready-to-mold stock is derived from reinforcements preimpregnated with epoxy resins. These pre-loaded materials can be processed over a wide range of pressing conditions, from as low as 10 psi to 1500 psi. Naturally, optimum properties are obtained only when optimum cure is effected and proper fabrication procedures are followed. In addition, specific epoxy systems are designed to meet specific application requirements. This discussion will attempt to describe the handling and curing procedures common to these epoxies when used for preimpregnated reinforcements, to apply these procedures to specific epoxy systems, and to mention both established and experimental systems providing serviceable laminates under conditions ranging from room temperature to 400°F. It will also attempt to draw some general conclusions, pointing out the future potential of these resins.

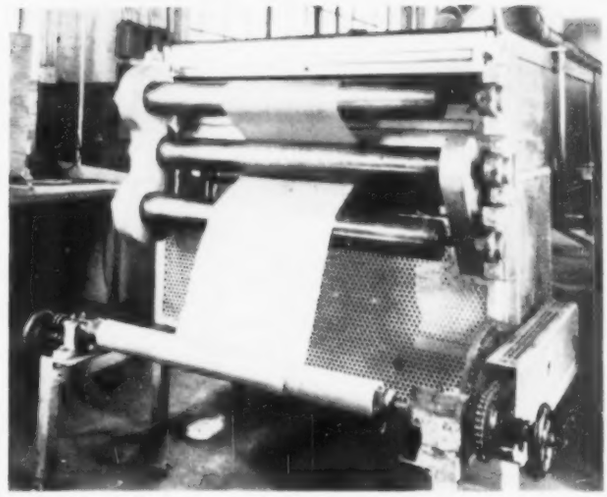
This paper was presented at the recent Symposium on Epoxy Resins, sponsored by the Southern California Section of S.P.E.

Optimum Cure

One of the most important considerations to bear in mind concerning epoxy resins is the dependence of their superior properties upon optimum cure. An initial moderate cure of epoxy laminates yields structurally sound parts with the expected epoxy properties at moderate service conditions. At elevated temperatures, however, these properties, particularly chemical resistance and electrical and mechanical properties, are retained only by "full" cure. Epoxide polymerization reactions, unlike those of polyesters, are step-by-step processes and require more stringent conditions for "full" cure. "Full" cure with its attendant bonus properties is approached by postcuring at elevated temperatures. The effect of postcure on glass cloth laminates preimpregnated with three different epoxy systems is shown in Table I.

Dry lay-ups for commercial applications can be made from liquid epoxy resins hardened with aromatic amines, solid epoxy resins, blends of solid and liquid resins, and modified epoxy resins. The proper resin-hardener choice is predicated largely by the handling and end use requirements. For good mechanical and electrical properties under moderate temperature service conditions, the solid resins or a modified epoxy generally provide the most satisfactory performance. At higher temperatures, a laminate preimpregnated with a liquid resin of the bis-phenol type usually performs best. Most commercial facilities call for impregnating the reinforcement from a solvent solution of the catalyzed resin. Most treaters for this work use a dip tank and doctor bars, or squeeze rolls followed by solvent removal, and advancing the resin to a partial cure. This condition of partial cure, which is a definite stage in resin cure, is called "B" stage, a term originated by Dr. Baekeland many years ago in his original thermo-





Photos show the machine used for pre-impregnating glass cloth with epoxy resin. Resin pick-up at left, and drying end above.

setting work. In this stage the resin, although solid, is readily fuseable when subjected to additional heat or pressure.

The procedure described above was followed in the laboratory in treating the stock on which the following tables of data are based. Figures 1 and 2 show the resin pick-up end and the wind-up end of the laboratory treater. Treating conditions in this thirty-foot treater consisted of a wet end temperature of 278°F., a controllable dry end temperature, and a speed of about six feet per minute.

Among the solvents for epoxy resins are acetone, ethyl acetate, methyl ethyl ketone, and toluene-isopropanol. The average resin content of such a solution is about 60 per cent. This gives an extremely easy to handle varnish with viscosities in the 20 to 300 cst. range. Depending on the resin used, a one to three weeks pot life can be expected after the resin solution has been catalyzed. In laboratory work, 181 "Volan-A"* finished glass cloth was used for the reinforcement. Generally, the resin content of the stock is kept between 25 and 36 per cent. This is controlled at the resin pick-up end by the dip roll and doctor bars. The volatile matter content of the treated stock is under one per cent, while its flow is 8 to 12 per cent at the pressure used for laminating. The shelf life of the finished stock ranges from a few days to over a year depending on the epoxy hardener system and drying conditions.

Product of E. I. du Pont de Nemours and Company

Dry Lay-up

Significant from the commercial applicator's point of view is the effectiveness of epoxy dry lay-ups over a wide range of pressing conditions. By varying drying and initial treating operations, the superior performance of these laminates remains unchanged when pressed at different pressures. Advancing the initial cure produces stocks that can be pressed at higher pressures; retarding the cure produces stocks for pressing at lower pressures. As a result of this versatility, lay-ups preimpregnated with epoxies can be easily adapted to most plant pressing conditions. Naturally, this same versatility enables the commercial processor to choose the pressing operation which is most suitable, both from the standpoint of desired end properties as well as economy, for his specific

Table I

Effect of Postcure on Epoxy-Glass Cloth Laminates

Resin System——Property	Press Cure Only	Postcured 8 hrs. 160°C, 320°F
ELS-3001		
Arc Resistance, sec.	40	150-180
Flexural Strength @ 160°F, psi	20,000-30,000	53,000-63,000
Flexural Modulus @ 160°F, psi	1.5-2.5 x 10^5	3.0-3.4 x 10^5
EKRA-2002/4,4′ MDA		
Arc Resistance, sec.	80	180
Flexural Strength @ 160°F, psi	58,000-62,000	70,000-72,000
Flexural Modulus @ 160°F, psi	3.2-3.4 x 10^5	3.8-4.0 x 10^5
EKRD-2003/4,4′ MDA		
Arc Resistance, sec.	80	185
Flexural Strength @ 160°F, psi	68,000-70,000	80,000-82,000
Flexural Modulus @ 160°F, psi	3.4-3.6 x 10^5	4.0-4.2-10^5

Press Cure: 1 hr. at 325°F, and 300 psi from preimpregnated glass cloth
Resin Content — 32%

application. Table II shows nearly identical properties resulting from laminates of the same epoxy treated to be pressed at four different pressures.

The laminates pressed at 225 psi and 400 psi were dried for 7 minutes in the laboratory treater at a dry end temperature of 298°F. Decreasing the dry end temperature to 278°F. gave a stock which could be vacuum bag molded. A commercial run of this material was made in which the stock was dried for 7 minutes at 302°F. and pressed satisfactorily at 1000 psi.

Table II

Mechanical Properties of ELS-3001 Laminates Treated for Pressing at Different Pressures

Pressed At 400 psi	
Flexural Strength, psi	85,000
At 160°F., psi	65,000
After 2 hr. Water Boil, psi	75,000
Tensile Strength, psi	60,000
Edgewise Compressive Strength, psi	53,000
Cure Conditions—325° F. for one hour	
Postcure Conditions—320° F. for eight hours	
Pressed at 400 psi	
Flexural Strength, psi	80,000-85,000
At 160°F., psi	53,000-63,000
After 2 hr. Water Boil, psi	72,000-80,000
Tensile Strength, psi	55,000-60,000
Edgewise Compressive Strength, psi	50,000-55,000
Cure Conditions—320° F. for one hour	
Postcure Conditions—320° F. for eight hours	
Pressed At 225 psi	
Flexural Strength, psi	77,000
Tensile Strength, psi	58,000
Edgewise Compressive Strength, psi	54,500
Cure Conditions—320° F. for one hour	
Postcure Conditions—320° F. for eight hours	
Pressed at 1,000 psi	
Flexural Strength, psi	80,000
Tensile Strength, psi	57,000
Edgewise Compressive Strength, psi	54,000
Cure Conditions—340° F. for one hour	
Postcure Conditions—300° F. for two hours	

Table III

Mechanical Properties of 1/8 in. ELS-3001 Laminates

Catalyst: 0.5 % alpha methyl benzyldimethylamine
Reinforcement: 181 "Volan-A" finished glass cloth
Cure: Press-cured 1 hour at 160°C. and 400 psi
Post-cure: 8 hours at 160°C.

Flexural Strength, psi	80,000-85,000
Flexural Modulus, psi	3.8-4.5 x 10^6
Flexural Strength at 160°F., psi	53,000-63,000
Flexural Modulus at 160°F., psi	3.0-3.4 x 10^6
Flexural Strength after 2 hr. H_2O boil, psi	72,000-80,000
Flexural Modulus after 2 hr. H_2O boil, psi	3.7-4.3 x 10^6
Tensile Strength, psi	55,000-60,000
Tensile Modulus, psi	3.8-4.4 x 10^6
Edgewise Compressive Strength, psi	50,000-55,000
Edgewise Compressive Modulus, psi	4.0-4.6 x 10^6
Izod Notched Impact Strength, ft. lb. in.	11-13
Rockwell Hardness	M104-M108
24 hr. Water Absorption, % weight gain	0.02-0.07

Table IV

Comparative Flexural Strengths Under Different Testing Conditions of Laminates Preimpregnated with ELS-3001

Conventional Flexural Strength, psi	80,000
1,000 Hour Flexural Strength in air at 77°F., psi	47,000
10^7 Cycle Flexural Fatigue Stress, psi	18,500
Reinforcement: 181 "Volan A" finished glass cloth (1/8" lam.)	
Cure: Pressed 1 hour at 320°F. and 400 psi	
Postcure: 320°F. for 8 hours	

An example of a moderate service temperature resin which by far exceeds the requirements of Military Specifications MIL-P-18177 type GEE and MIL-R-7575 is a modified epoxy catalyzed with a high boiling tertiary amine. At room temperature this resin is normally a pitchlike material. To aid the laminator in processing, a 70 per cent solids solution of this resin in toluene is available. The solution version of the modified epoxy is easier to process at most laminating plants since it can be handled like any standard phenolic laminating varnish. The resin may be cut to treating viscosity with alcohol. One half percent by weight on the resin solids of alpha methyl benzyldimethyamine[1] is added to the solution as catalyst. Laboratory solutions were 58 to 60 per cent solids. This catalyst is a high boiling liquid which is easily mixed with the resin solution. Catalyzed solutions have been useful after two to three weeks.

The modified epoxy is unsurpassed in toughness by any epoxy yet evaluated (Table III). These are typical properties of laminates made from 181 "Volan-A" cloth, pressed at 400 psi for one hour at 320°F with a postcure of 8 hours at the same temperature. At room temperature these laminates have a flexural strength in the 80,000 psi to 85,000 psi range and an edgewise compressive strength, this being a measure of its bond strength, of 55,000 to 60,000 psi. In a standard flexural fatigue strength test, the 10^7 cycle strength of these laminates was as much as 24 per cent of its conventional flexural strength (Table IV). Structures with this epoxy system still perform well at temperatures up to 160°F.

Electrical properties of this system are shown in Table V. Because of this superior performance, this resin is finding a growing use in high-quality electrical grade laminates and electrical tubing, printed circuits, and honey comb structures.

Another outstanding advantage of stock treated with a modified resin, is long shelf life. Two years after being treated, laminates of this epoxy can still be pressed. The unusual strength properties of this resin, coupled with this exceptionally long shelf life, make it one of the most attractive members of the epoxy group.

Very good mechanical and electrical properties at temperatures of 160°F. to 200°F. are obtained with prepregs using solid resin systems. These brittle or grindable resins are normally put into solution before use. In the laboratory, this was accomplished by coarse grinding the resin, putting it in a container with solvent, and placing the mix on rolls (Table VI). The data shown on these solid or brittle resins are based on laminates of the resin hardened with stoichiometric amounts of the stripped grade of 4,4' methylene dianiline,[2] although equivalent properties have been obtained using catalytic amounts of certain amines. Eleven parts per hundred of 4,4' MDA were used with the first of the two resins illustrated and 5½ parts per hundred with the second resin. The 4,4' MDA is a solid but readily dissolves in the solvent used for the resins. It may be added to the resin-solvent mix before the brittle resins are put into solution, if the solution is to be used within a week, or it may be dissolved in solvent and added to the resin solution just before treating. Treating solutions of the solid resin/hardener systems have a 58 to 60 per cent solids

[1] *Product of Carbide and Carbon Chemical Company, a Division of Union Carbide and Carbon Corporation.*
[2] *Product of Dow Chemical Company, Midland, Michigan*

content and have remained useful for a week after preparation.

Treating, pressing and post cure conditions were the same as those for the modified epoxy described earlier. As it did with the modified epoxy, post curing the laminates improved the arc resistance, the elevated temperature electrical and mechanical properties, and the resistance to water as indicated by the power factor after water immersion conditioning. Shelf lives of the treated stock to date are over six months. These figures are the ages of the oldest samples on hand; shelf lives beyond these listed periods are expected.

Another attractive feature of the modified epoxy is that the low-frequency power factors are degraded by water immersion markedly less than those of the brittle resins. Laminates of this resin have been exposed on the laboratory roof for 12 months with no sign of leaching. After 12 months exposure there was no loss of strength.

The biggest advantage offered over other materials is the ease of handling obtained with modified epoxy. This low viscosity solution is readily handled and no heating or rolling of the resin in contact with solvent is necessary. The small amount of liquid catalyst and additional solvent can be added without difficulty.

The modified epoxy and the solid epoxy resins make lightweight, good weathering, chemically-resistant structural materials. These materials exhibit exceptionally good strength values. However, this strength is obtained at a sacrifice in heat distortion. A liquid epoxy resin of the bis-phenol type makes elevated-temperatures-service

Table V

Electrical Properties of 1/8 in. ELS-3001 Laminates

Catalyst: 0.5% alpha methyl benzyldimethylamine
Reinforcement: 181 "Volan-A" finished glass cloth
Cure: Press-cured 1 hour at 160°C. and 400 psi
Post-cure: 8 hours at 160°C.

Arc Resistance, sec.	150-180
Western Electric Insulation Resistance, megohms	1-3 x 10^7
Dielectric Strength	
Cond A	
perpendicular to laminations, volts/mil	450-500
parallel to laminations, KV	45-50
Cond D48/50	
perpendicular to laminations, volts/mil	350-450
parallel to laminations, KV	40-45
One Megacycle	
Cond A	
Power Factor	.010- .018
Dielectric Constant	4.2 -4.9
Loss Factor	.04 - .09
Cond D24/23	
Power Factor	.010- .020
Dielectric Constant	4.6 -5.1
Loss Factor	.05 - .10
Cond D48/50	
Power Factor	.014- .021
Dielectric Constant	5.0 -5.2
Loss Factor	.06 - .11

Table VI-A

Dry Lay-up Laminates Electrical Properties
(Epoxy Resins on 181 "Volan-A" Glass Cloth)

Resin:	ELS-3001	EKRA-2002	EKRD-2003
Curing Agent:	1/2% α me BDMA	11 pph 4,4' MDA	5 1/2 pph 4,4' MDA
Arc Resistance seconds	150-180	140-180	155-185
Western Electric Insulation Resistance megohms	1-3 x 10^7	1 x 10^6	1-3 x 10^6
Dielectric Strength			
Cond A			
perpendicular to laminations, volts/mil	450-500	450-480	450-500
parallel to laminations, KV	45-50	45-50	37-42
Cond D 48/50			
perpendicular to laminations, volts/mil	350-450	300-350	350-450
parallel to laminations, KV	40-45	40-45	37-42
One Megacycle			
Cond A			
Power Factor	.010- .018	.015- .018	.010- .014
Dielectric Constant	4.2 -4.9	4.5 -4.7	4.7 -4.9
Loss Factor	.04 - .09	.07 - .09	.05 - .07
Cond D 24/23			
Power Factor	.010- .020	.019- .021	.015- .018
Dielectric Constant	4.6 -5.1	4.5 -4.9	4.8 -5.1
Loss Factor	.05 - .10	.09 - .10	.08 - .09
Cond D 48/50			
Power Factor	.014- .021	.021- .025	.015- .020
Dielectric Constant	5.0 -5.2	4.6 -5.2	4.9 -5.2
Loss Factor	.06 - .11	.11 - .12	.08- .10

Table VI-B

Dry Lay-up Laminates Mechanical Properties (Epoxy Resins on 181 "Volan-A" Glass Cloth)

Resin:	ELS-3001	EKRA-2002	EKRD-2003
Flexural Strength, psi	80,000-85,000	80,000-85,000	95,000-100,000
Flexural Modulus, psi	3.8-4.5 x 10^6	3.6-3.9 x 10^6	4.4-4.6 x 10^6
Flexural Strength at 160°F, psi	53,000-63,000	69,000-74,000	70,000-75,000
Flexural Modulus at 160°F, psi	3.0-3.4 x 10^6	3.5-3.7 x 10^6	4.0-4.2 x 10^6
Flexural Strength after 2 hr. water boil, psi	72,000-80,000	77,000-79,000	85,000-90,000
Flexural Modulus after 2 hr. Water boil, psi	3.7-4.3 x 10^6	3.4-3.7 x 10^6	3.8-4.0 x 10^6
Tensile Strength, psi	55,000-60,000	52,000-59,000	61,000-66,000
Tensile Modulus, psi	3.8-4.4 x 10^6	2.9-3.4 x 10^6	3.5-4.0 x 10^6
Edgewise Compressive Strength, psi	50,000-55,000	45,000-50,000	48,000-52,000
Edgewise Compressive Modulus, psi	4.0-4.6 x 10^6	3.5-3.7 x 10^6	3.9-4.5 x 10^6
Izod Notched Impact Strength ft. lb./in.	11-13	12-15	16-18
Rockwell Hardness	M104-M108	M110-M112	M102-M107
24 hr. Water Absorption % weight gain	0.02-0.07	0.04-0.06	0.04-0.08

Laminates press cured 1 hour at 160°C. and 400 psi. Postcured 8 hrs. at 160°C. ($\frac{1}{8}$" lam.)

Table VII

Dry Lay-up Laminate Properties (On 181 "Volan-A" Glass Cloth)

Resin: ERL-2774
Hardener: 4,4' MDA

	At Room Temperature	At 260°F	After 2 hr. Water Boil	At 300°F
Flexural Strength, psi	79,000-89,000	52,000-60,000	77,000-82,000	40,000-50,000
Flexural Modulus, psi	3.6-3.9 x 10^6	3.0-3.5 x 10^6	3.2-3.6 x 10^6	2.6-2.9 x 10^6

CONDITIONS AT ROOM TEMPERATURE

Tensile Strength, psi	50,000-58,000
Tensile Modulus, psi	3.3-3.6 x 10^6
Edgewise Compressive Strength, psi	49,000-51,000
Edgewise Compressive Modulus, psi	3.5-3.6 x 10^6
Rockwell Hardness	M115-M117
Izod Notched Impact Strength, ft. lb. in.	12-15
24 hr. Water Absorption, % weight gain	0.05-0.07
Arc Resistance, seconds	130-180
Western Electric Insulation Resistance, megohms	5-10 x 10^3

	Cond. A	Cond. D 24/23	Cond. D 48/50
Dielectric Strength			
perpendicular to laminations, volts/mil	500-550	———	400-500
parallel to laminations, KV	55-65	———	42-50
One Megacycle			
Power Factor	.017- .019	.010- .025	.010- .035
Dielectric Constant	4.2 -4.6	4.4 -4.8	4.6 -5.3
Loss Factor	.07 - .09	.08 - .12	.10 - .20

Pressed 1 hr. at 160°C (320°F)
Postcured 2 hrs. at 300°F + 6 hrs. at 400°F

structural materials possible. Lay-ups prepared in the laboratory from a typical commercial epoxy of medium viscosity, hardened with an aromatic amine, had good mechanical and electrical properties at temperatures up to 300°F.

The laminates were preloaded with an acetone solution of the resin/hardener mix composed of approximately 65 per cent solids. For the aromatic amine hardener, 29.5 parts of 4,4' methylene dianiline were used per hundred parts of resin. For convenience in preparing the solution, the 4,4' MDA was first dissolved in the solvent and then the liquid resin was added. After two weeks the solution could still be used to impregnate cloth. The impregnated cloth was dried in the treater oven for about 9 minutes at 278°F. and was treated to press at 200-400 psi. Laminates of this resin, when treated for pressing at these pressures, had a useful shelf life of 30 to 35 days when stored at ambient room temperature. Lower temperature storage would prolong this shelf life period.

The laminates were postcured in an oven for two hours at 300°F. followed by 6 hours at 400°F. Room temperature mechanical properties of the laminates were very good, as were the electrical properties, but the outstanding characteristic of this material was its retention of a high percentage of room temperature strength when tested at elevated temperatures (Table VII). At 300°F. these panels still showed flexural strengths of 50,000 psi. This system also performed well in stress-corrosion-rupture tests designed to determine the maximum stress a material can support for 1,000 hours in water at room and elevated temperatures (Table VIII).

By treating glass cloth with the modified or solid resins for moderate temperature service, and treating with a bis-phenol resin for elevated temperature conditions, superior grades of structural and electrical lami-

Table VIII

Flexural Strength of Laminates Preimpregnated With Epoxy Resin ERL-2774 and Hardener 4, 4 'MDA

Conventional Flexural Strength in Air (psi)		1000-Hour Flexural Strength in Water (psi)	
77°F.	140°F.	77°F.	140°F
64,600	64,400	44,000	22,000

Reinforcement: 181 "Volan-A" glass cloth (⅛ inch lam.)
Cure: Pressed 1 hour at 320°F.
Posteure: 2 hours at 300°F. + 6 hours at 400°F.

Table IX

Comparative Glass Cloth Laminate Properties
181 Weave Glass Fabric

Resin	Modified Epoxy ELS-3001	Polyester	Phenolic
Flexural Strength, psi	80,000-85,000	60,000-65,000	75,000-80,000
Flexural Modulus, psi	3.8-4.5 x 10⁶	3.0-3.3 x 10⁶	4.0-4.3 x 10⁶
Tensile Strength, psi	55,000-60,000	43,000-47,000	50,000-55,000
Compressive Strength, psi	50,000-55,000	35,000-40,000	48,000-52,000
Power Factor @ 1 megacycle	.010-.015	.010-.011	.023-.025
Arc Resistance, seconds	150-180	155-180	20-40
24 hr. Water Absorption % Weight Gain	0.02-0.07	0.2-0.3	0.3-0.6

⅛" Laminate, Resin Content 32%

Table X

Mechanical Properties of Laminates Preimpregnated with an Experimental Epoxy

Flexural strength, psi	85,000-95,000
Modulus	4.0-4.2 x 10⁶
Flexural strength at 260°F., psi	65,000-70,000
Modulus	3.9-4.0 x 10⁶
Flexural strength at 300°F., psi	60,000-65,000
Modulus	3.7-3.9 x 10⁶
Flexural strength at 400°F., psi	40,000-47,000
Modulus	3.0-3.5 x 10⁶
Tensile strength, psi	57,000-59,000
Modulus	3.0-3.5 x 10⁶
Edgewise Compressive strength, psi	49,000-53,000
Modulus	4.0-4.2 x 10⁶

Reinforcement: 181 "Volan-A" glass cloth
Cure: Pressed 1 hour at 320°F. and 400 psi
Posteure: 320°F. for 8 hours.

Table XI

Electrical Properties of ⅛ in. Glass Cloth Laminates At Different Temperatures

ELS-3001			70°C	100°C
Power Factor, IMC			.007	.0085
Dielectric Constant, IMC			5.26	5.46
Loss Factor			.036	.046
ERL-2774	**100°C**	**150°C**	**205°C**	
Power Factor, IMC	.012 - .013	.0066- .0083	.012 - .015	
Dielectric-Constant, IMC	4.7 -5.3	5.36 -5.44	5.42 -5.48	
Loss Factor, IMC	.058 - .065	.036 - .045	.068 - .083	
Experimental Epoxy	**100°C**	**150°C**	**205°C**	
Power Factor, IMC	.012 - .013	.008 - .009	.0053- .0068	
Dielectric-Constant, IMC	4.67 -4.78	4.72 -4.80	4.67 -4.71	
Loss Factor, IMC	.060 - .061	.038 - .044	.030 - .032	

nates designed to meet a variety of production requirements are possible with epoxy resins. From this discussion it can be seen there are excellent reasons why epoxies are establishing themselves in the field of reinforced plastics. As a result of this superior performance these relatively new resins have made striking advances in the areas long dominated by the older thermosetting plastics, polyesters and phenolics. Table IX shows typical average properties of epoxy, polyester and phenolic glass cloth laminates. It is evident that the epoxy laminate is superior to the phenolic in electrical properties, is superior to the polyester in mechanical properties, and surpasses both in water resistance. Although mechanical strengths, electrical properties, and chemical resistance of reinforcements preimpregnated with epoxy resins are suitable for today's normal needs, future development must improve on these. Continuing investigation and experiments are already succeeding in raising still further the superiority of the epoxy resin. One of the most challenging recent developments evaluated in our laboratories has been the appearance of an epoxy which provides good service strength at a temperature of 400°F. An anhydride hardener was used with this experimental epoxy, and it was solvated, treated and dried in the same manner as the conventional resins mentioned before. Cure and post-curing conditions were the same as those for the modified and solid epoxies.

Tested at 400°F, this system retained a higher degree of its room temperature strength than any epoxy yet evaluated, showing a flexural strength of 40,000 psi to 47,000 psi (Table X). These laminates also displayed notably good bond strengths. As with all epoxy resins, the electrical properties of the experimental epoxy were only slightly affected by increased temperatures and were still considerably above minimum requirements. (Table XI). The shelf life of laminates treated with this new resin is only a few days and still too short for use in commercial applications. However, we feel it aptly illustrates the goals Development is aiming for and expecting to achieve.

Epoxies have come a long way in the short length of time since their commercial introduction to this country. If the future of reinforcements preimpregnated with these resins may be fairly evaluated on the basis of advances made to date, rapid expansion in this field will undoubtedly continue. The promise for extending epoxies to applications where high temperature conditions must be met is already close to fulfillment. This and other improvements in the development stage, such as epoxy resins with increased flame retardency, water resistance, and chemical resistance will have far reaching and rewarding effects on the industrial use of epoxy preimpregnated reinforcements.

Where do you fit into this

Products of PLASKON Plastics and Resins in this kitchen:

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Urea—electric blender base, radio housing, electrical outlet and switch plate, can opener
Melamine—dinnerware, washing machine agitator, utensil handles
Polyester Resins—translucent panels, chair

Barrett PLASKON

picture?

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...LEADER IN THE FIELD

Property–Structure Relationships in Polyethylene

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In spite of the great interest that has been displayed in the Ziegler polymerization process, very little factual information is as yet available about the molecular properties of polyethylene that may be produced. This is in contrast to the more complete story that is available about polymers of other olefins and about polyethylenes obtained by other methods. As a consequence, there is a tendency to lump all polyethylenes made by variants of the Ziegler process into a single series, with the individual polymer samples differing only in molecular weight.

It was soon apparent to the workers at the Hercules Research Center that, in actuality, wide differences existed between products of the same solution viscosity. It now appears that these differences may be traced to chemical differences in the polymer chains. It is convenient to classify these differences in three main categories: (1) Functional group content; (2) Linearity; and (3) Distribution of molecular weight.

From our investigations it seems probable that ethylene polymers derived from Ziegler-type catalyst systems will eventually group themselves in a manner based on the above variables. These groups will be characterized by (1) high linearity with narrow molecular weight distribution, (2) high linearity with broad distribution, and (3) moderate linearity with intermediate distribution. Each of these types will have distinctive advantages for certain applications. We shall attempt to show, in this paper, how these structural details affect physical properties of molded plastics.

In the Hercules processes we have operated within the range 0-100°C and at less than about five atmospheres total pressure, using as catalyst certain combinations of reactive metal alkyls and transition metal compounds. In much of the work reported in this paper, aluminum alkyls were used in conjunction with titanium compounds. It is unfortunately not possible at the present time to give details of polymerization processes.

The methods of characterization usually followed standard practice very closely. Functional group content was determined largely by infrared methods. Linearity was judged on the basis of methyl group content, as determined by infrared, as well as by density and melting point. To determine molecular weight distribution it was necessary to develop a fractionation method of suf-

Table I
Polyethylene Properties

Polymer	Experimental Samples				Samples from High-Pressure Processes	
	A	B	C	D (1)	E (2)	F (3)
Physical Properties						
RSV Flake (deciliters/gram)	2.3	2.3	2.2	2.3	1.1	1.1
M_w/M_n	3.6	7.0	9.3	10.4	High	
Crystalline Melting Point, °C.	137	132	135	136	111	118
Crystallinity by infrared (maximum achieved on annealing)	85%	79%		91%	59%	–
Chemical Properties						
Methyl, %	0.05	0.86	0.29	0.19	3.22	2.03
Vinyl, %	0.036	0.044	0.014	0.27	0.006	ND (4)
Vinylidene, %	0.006	0.007	0.003	0.004	0.020	0.011
Trans vinylene, %	0.004	0.024	<0.003	0.014	0.003	ND (4)
Plastic Properties						
Tensile strength, lb./sq. in.	3500	2900	–	3400	2170	2170
Tensile modulus, lb./sq. in.	143,000	100,000		170,000	25,000	39,000
Flexural stiffness, lb./sq. in.	89,000	64,000		101,000	24,800	29,000
Rockwell hardness	47R	36R	–	55R	12R	3R
Izod impact, ft.-lb./in. notch	7.3	2.8		5.5	13	15
Torsional rigidity T_{100}, °C.	87	75		78	34	36
Sp. gravity at 23°C.	0.951	0.945		0.955	0.922	0.927
Elongation of compression-molded resin, %	>2200	800	–	300–900	450	730

(1) Linear polymer made by non-Ziegler, low-pressure process; obtained from Phillips Chemical Company
(2) High pressure, branched chain polymer; obtained from E. I. du Pont de Nemours and Co., Inc.
(3) High pressure, intermediate density, branched chain polymer; obtained from E. I. du Pont de Nemours and Co., Inc.
(4) Under detection limits.

ficient reproducibility to allow valid comparisons between the various types of products. This method, together with the necessary work on molecular weight determination, has been reported in a separate paper (1).

Characterization of polyethylenes made by numerous variations of Ziegler catalysts showed that their linearity and molecular weight distribution can be varied over a considerable range (See experimental samples A, B, and C in Table I). Two were chosen for more extended testing of physical properties. These were: (A) a product of seemingly perfect linearity, relatively narrow distribution of molecular weight; and (B) a slightly less linear product with a wide distribution of molecular weight. A sample of polyethylene prepared by another low-pressure process (sample D) and two commercial high-pressure, considerably branched polyethylenes (samples E and F) were also tested for comparison.

For most of the work reported in this paper (See Table I), specimens of these types in the injection molding range of viscosity were needed. Samples were therefore chosen of reduced specific viscosity (RSV), measured at 0.1% in decalin at 135°C., of 2.2 to 2.3. This corresponds to an intrinsic viscosity of about 2.0.

A few words are in order about products outside this range of molecular weight. In general, the same type of variation is observed. Linear products of very high molecular weight (RSV greater than 20) have been prepared; they do not have detectable methyl group content, and many do not have detectable unsaturation. Some products are so high in viscosity that they do not go into solution in the routine viscosity determination. This behavior is not believed to be due to cross-linking in all cases, though it should be remarked that cross-linking accompanies mild oxidation, which may have occurred during processing. Products of methyl group content up to 1.3% have also been obtained, even at such high viscosity levels that end groups of linear chains could not be a large contributing factor. It is believed that the degree of branching can be made even higher and varied over the whole range of molecular weight. The distribution of molecular weights has been followed only over the range of RSV from 1.5 to 5. Throughout this range products of both narrow and wide distribution of molecular weight have been observed. No product with both narrow distribution and high degree of branching has been observed.

Methods of Characterization

Descriptions of the methods are given in the experimental section.

Since one of the significant results of this work is the discovery that products of fairly narrow distribution of molecular weight can be prepared, a justification of the method of evaluation is desirable. In common with other workers (3), we felt that the best single criterion of the breadth of the distribution curve was the ratio of weight-average to number-average molecular weight (M_w M_n). The weight-average molecular weight of a polymer, M_w, is based on the total weight of the particles of each size present, and is defined as:

$$\frac{\Sigma\, W\, M}{\text{Total } W}$$

where W = weight of all molecules of each size; M = molecular weight; and Total W = total weight of all molecules.

The flow characteristics and the viscosity of a polymer are more closely related to M_w than to M_n. The number-average molecular weight, M_n, is based on the number of particles present, and is defined as:

$$\frac{\text{Total weight of all molecules}}{\text{Total number of moles}}$$

The usefulness of M_n depends on the fact that it is inversely related to the number of chain ends, which may be points of weakness in a plastic structure. The ratio of these two numbers is a well-recognized term in polymer work, but it is not necessary to determine the two factors separately. The ratio can be derived from an analysis of the distribution curve. The fractionation method developed in our laboratories, as mentioned above (1), is a modified Desreux technique, and was found to be reproducible and only moderately time-consuming. It allows the samples to be placed in the correct order of breadth of distribution, thereby enabling a correlation of distribution of molecular weight with physical properties of plastics.

Plastics Properties

In order to compare the effect of molecular structure on physical properties, analytical and mechanical data are assembled in Table I for polymers typical of the various systems with which we have been working. Sample A is a highly linear polymer (methyl = 0.05%) of narrow distribution (M_w M_n = 3.6); sample B is somewhat less linear in its molecular skeleton (methyl = 0.86%) and has substantially broader distribution (M_w M_n = 7) than sample A. The third of our experimental polymers, sample C, has rather high linearity (methyl = 0.29%) and the broadest distribution of the three (M_w M_n = 9.3). Sample D is a linear ethylene polymer (methyl = 0.19) made by a different low-pressure process and obtained from another company. Fractionation indicated a rather broad distribution of molecular weight (M_w M_n = 10.4). It is apparent that all of the low-pressure polymers in this series whose properties have been tested are far stronger, stiffer, harder, and more resistant to high temperatures than the high-pressure, highly branched polymers (samples E and F).

The lower degree of crystallinity and greater flexibility of sample B compared to sample D is readily explained by the higher methyl group content in the former. However, the relative values of properties of molded specimens of A and D were unexpected. Structurally the two appear to differ principally in molecular weight distribution; both are highly linear. The crystallinity values shown in Table I, as determined by infrared spectroscopy, represent the maximum levels which can be attained by careful annealing of film. On the other hand, the plastics properties were determined on injection-molded pieces in which the degree of crystallinity was probably not as high. However, the physical properties, as measured at room temperature, testify that sample D is somewhat more highly crystalline than A. At elevated temperature, the relative stiffness of the two materials is reversed.

The lower crystallinity of sample A is not due to some form of molecular imperfection which has escaped detection. The melting point is high, and the high torsional rigidity at elevated temperatures indicates that the crystallites in sample A are stable. The temperature corresponding to a torsional rigidity of 4000 lb./sq. in. is 87°C., compared with 78°C. for sample D (See Torsional Rigidity under Experimental). It is therefore assumed that the controlling feature distinguishing these samples is the perfection of development of crystallinity during molding. Molded specimens of A are noticeably more transparent than D, suggesting the presence of smaller crystalline regions.

The following working hypothesis has been adopted to explain this situation. It is assumed that the velocity of crystallization is related to the number of chain ends in the sample. Consider, for example, a chain that is fitting itself to a growing crystalline region. If this chain has an end in the surrounding amorphous region, the chain end can readily diffuse to the surface of the crystalline region. If, however, this end of the chain has already been built into another crystalline nucleus, diffusion is impossible. The portion of the chain between the two crystalline regions will be forced to coil up in a random fashion in order to fit the available space. This will lead to a higher amorphous content of the sample having the lower number of chain ends. This theory agrees with the fact that linear polyethylenes of high molecular weight are in general more difficult to crystallize to a high density than samples of lower molecular weight.

Of course, this argument no longer holds in the vicinity of the melting point. Here, thermodynamic stability is more important than the rate of crystal growth. A large number of chain ends will lower the equilibrium melting point and even the per cent crystallinity at a temperature of 80-90 C. There is thus an explanation of the curious reversal in relative stiffness of A and D as the temperature is increased.

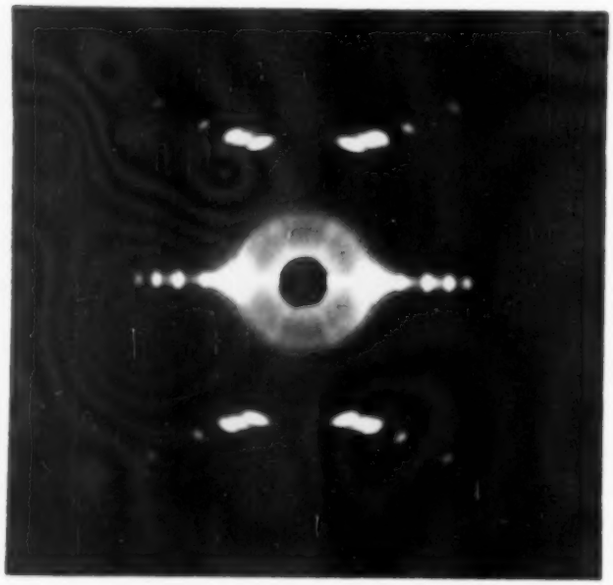


Figure 1 X-Ray Diagram of Highly Extended Polyethylene (Sample A)

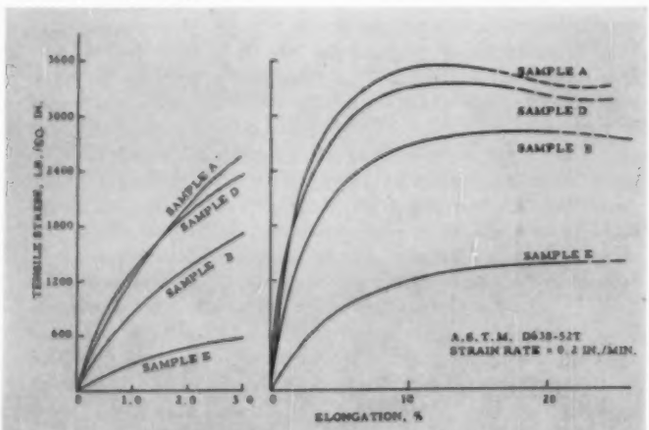


Figure 2 Stress-Strain Curves for Various Polyethylenes

A further discussion of the behavior under extension is justified. The extraordinary extensions (>2200%) observed with compression-molded specimens of sample A when drawn at 100% per minute is connected with extensive recrystallization. This is shown in the x-ray diagram of such an extended specimen (Figure 1) and is of significance in the preparation of oriented monofilaments. The stress-strain diagram for sample A (Figure 2) shows an initially lower modulus with the curve finally reaching a high load (3500 lb./sq. in. compared to 3400 lb./sq. in. for sample D) before the sample begins to neck-down and draw out. This behavior is illustrated in Figure 2. It may be assumed that sample A has been extensively recrystallized and oriented at its yield point, so that finally its degree of crystallinity is close to that of sample D. The intimate details of this process are probably associated with the temperature rises due to the large input of work during the stretching process just short of the yield point.

Sample B has lower initial crystallinity and is somewhat less linear than samples A and D because of its branching. For many applications, the properties represented by B are advantageous; for example, greater flexibility for cable and pipe use, greater resistance to stress corrosion in certain environments, and greater ability to flow into and fill large moldings having a deep draw.

The versatility of the Ziegler process and the Hercules modifications of it has been demonstrated in the present work, showing that the density or crystallinity range assigned to these processes in a recent paper (2), is, in fact, too narrow. We have prepared Ziegler polyethylenes with annealed densities as high as 0.960. Another pertinent factor in this versatility is that these polymers can be prepared at much higher molecular weight levels than we believe is practical with other low-pressure processes. While such high levels are impractical for many injection molding operations, they are entirely workable in extrusion equipment. It has been found that high molecular weight Ziegler-type polyethylenes offer important improvements in toughness and in stress-cracking resistance in wire and cable, pipe, and blown bottles.

We have so far not succeeded in preparing products by the Ziegler process that are similar in softness and extensibility to high-pressure polyethylene without resorting to copolymerization with other olefins, such as propylene. Our results with copolymers are similar to those reported by others (2).

Summary

It is possible to prepare very linear polymers by modification of the basic Ziegler process. Some modifications lead to products of high linearity and narrow distribution of molecular weight. Other modifications produce less linear polymers, with possibly an increase in internal unsaturation. This trend can be still further increased by copolymerization.

Narrow distribution and branching both lead to lower crystallinity and hardness in molded objects. The linear products of narrow distribution recrystallize, with resultant increase in modulus, when subjected to high loads or high temperatures. The less linear products do not exhibit this behavior to the same extent.

It may be anticipated that three types of product will find wide fields of use. These are (1) high linearity, narrow distribution, for uses requiring good impact resistance and extensibility in the as-molded condition, combined with good retention of properties at high temperature; (2) high linearity, wide distribution, for uses requiring hardness and high modulus in the as-molded condition; (3) less linear products, for applications demanding flexibility and

low modulus. It is recognized, however, that these are but preliminary observations, and that only extended field use will determine types of products best suited for different applications.

Experimental

Physical Properties

1. Reduced Specific Viscosity (RSV). Determined in Ubbelohde viscometer, using 0.1 per cent concentration of polymer in decalin at 135°C. Specific viscosity thus obtained was corrected to zero velocity gradient by means of the formula (1):

$$\eta_{sp}/\gamma = 0 = \eta_{sp}/1 - (0.00015)\ (\eta_{sp})\ (\gamma)^{\frac{1}{2}}$$

then converted to RSV by multiplying by ten.

2. Molecular Weight Distribution. A modified Desreux technique, described by Francis, Cooke, and Elliott (1), was used. A solution of polyethylene in xylene at 127°C was flowed into the upper part of a column of sand, then cooled and the xylene replaced by glycol monoethyl ether. About 15 fractions were obtained by eluting at 127°C with xylene — glycol monoethyl ether of progressively increasing solvent power. A smooth integral curve was drawn to fit the fractions obtained. This was approximated by blocks 10% wide for the bottom 50%, 5% for 50-90% of the curve, and 2% for the rest. The calculations of M_w and M_n were based on the assumptions that the blocks were uniform and that $[\eta] = 6.77 \times 10^{-4} M^{0.67}$.

3. Crystalline Melting Point. Based on disappearance of birefringence in sample after material has first been melted to relieve strains, recrystallized, then remelted. Continuous recorder was actuated by photoelectric cell. Heating rate was 3°C. per minute; rate of cooling during recrystallization was 7°C. per minute to a temperature below 100°C.

4. Crystallinity. Degrees of crystallinity values were based on the intensity of the absorption band in the infrared spectrum at 7.73 microns, which is characteristic of amorphous polyethylene. Samples were heated above the melting point and cooled at a rate of 0.67°C. per hour to about 100°C. Under those conditions it is believed that maximum crystallinity was developed in each sample.

Chemical Properties

Methyl group content and the various types of unsaturation in the polymers were determined by observation of the absorption at appropriate wave lengths in the infrared spectrum. These wave lengths and the precision of the determinations were as follows:

Methyl groups	7.25 μ	± 0.05%
Unsaturation		
Vinyl	11.0 μ	± 0.005%
Trans vinylene	10.35 μ	± 0.005%
Vinylidene	11.25 μ	± 0.005%

Plastics Properties

Those polymers in this study which were prepared in our own laboratories or pilot plant were converted to molding powder by extrusion at 410°F. No antioxidants or other additives were used. The other resins were in the form of commercial molding powders. The effect of stabilizers or additives normally expected to be present in the commercial samples has not been considered in this investigation.

Injection molding was done in a Moslo 1¼ ounce machine (Model 73-6). Properties were determined by standard ASTM methods wherever possible.

Tensile Properties

ASTM D638-52T — Dumbbell-shaped specimen, 8½ inches in overall length with center section ⅛ x ½ inch, was drawn at a constant rate of cross-head motion, 0.2 inch per minute, in a Baldwin Universal Tester. The high density polyethylenes showed a characteristically sharp yield point at about 15% elongation, after which the load required to extend the sample was considerably reduced and the specimen drew out several hundred per cent. For the high-density specimens A, B, and D, the tensile strength listed in Table I was calculated from the load at the maximum of the stress-strain curve and the original cross-section.

Because of slight differences in hardness and density from one end of an injection molded bar to another in the high density polymers, these pieces did not provide satisfactory data on ultimate elongation. To obtain relative extensibility figures, sheets 0.075 x 6 x 6 inches were compression-molded from the various resins. Strips ½-inch wide were cut from these sheets and tested in an Instron Tensile Tester at a rate of extension of 100% per minute. Ultimate elongation of these samples is noted in the table of properties.

Flexural Stiffness

ASTM D747-50—The injection-molded specimen is the same as that used in the torsional tests, 0.070 x 0.25 x 2.5 inches. Resistance to bending was measured in the Tinius-Olsen Stiffness Tester, using a 1-inch span.

Rockwell Hardness

ASTM D785-51—Disks ⅛ x 2 inches were used in the Rockwell Hardness Tester with the R scale. The low density resins are too soft to be expressed practically on this scale but are shown here to provide relative values.

Impact Strength

ASTM D256-54T—Original injection-molded bars were ¼ x ½ x 5 inches. These were cut in half, notched, and tested on a 50 in.-lb. Tinius-Olsen Impact Machine. In most cases the bars did not break through completely but were left hanging together by an outer skin.

Torsional Rigidity

ASTM 1043-51—This method, developed originally as a means of evaluating the low temperature stiffness of vinyl plastics, has been used extensively in our laboratory as a convenient means of assessing the rigidity of our polyethylene resins at elevated temperatures. The test specimen, 0.070 x 0.25 x 2.5 inches, was twisted in the Clash-Berg Apparatus while immersed in ethylene glycol. Apparent modulus of rigidity was determined at increments of 10°C. and plotted against temperature on semilog paper. For purposes of tabulation we have arbitrarily chosen the temperature at which this modulus is 4000 lb./sq. in. A high value of T_{4000} is thus a criterion of retention of stiffness at elevated temperatures.

Specific Gravity (23°C./23°C.)

ASTM D792-50—The ⅛ x 2-inch molded disk was used for this determination, weighed in air and in ethyl alcohol at 23°C.

References:

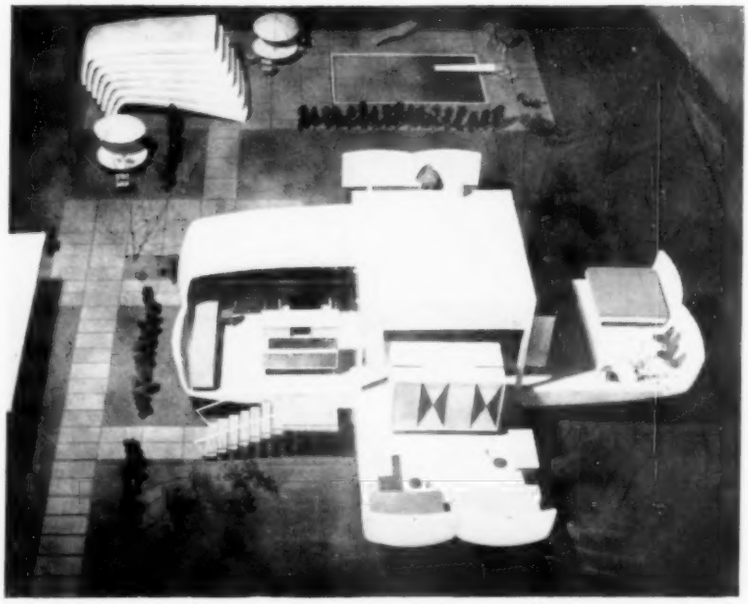
(1) P. S. Francis, R. C. Cooke, Jr., and J. H. Elliott; presented before Division of Polymer Chemistry, at the 130th meeting of the American Chemical Society, Atlantic City, New Jersey, September 19, 1956.

(2) R. V. Jones and P. J. Boeke, **Ind. Eng. Chem. 48**, 1155 (1956).

(3) E. T. Darden and C. F. Hammer, **Materials and Methods**, Vol. 44, No. 3, p. 94 (Sept. 1956).

ENGINEERING the Plastics House

Albert G. H. Dietz[1], Frank J. Heger, Jr.[2] and Frederick J. McGarry[3]



. . . how good is a plastics house? Here are the engineering details and material problems encountered . . .

IN THE DESIGN and construction of the House of Tomorrow under a project sponsored by the Monsanto Chemical Company, an effort was made to develop a plan which would be logical from the standpoint of living and, at the same time, would be unencumbered by preconceived notions respecting the plan of a house as built by traditional materials. The underlying thought was that plastics should, as far as possible, be used in this house as plastics rather than as substitutes for other materials. Every effort should be made to use plastics if they could logically be used, but for any sections of the house in which plastics would not be logical construction materials other materials were to be employed.

The architectural considerations led to a cross-shaped house consisting of a core with four wings. In the core are grouped the utilities including the baths, kitchen, laundry space and other working areas of the house. In the four wings are grouped the living quarters including living area, dining area and sleeping areas. Entrances to the house are at or near the core, and the housewife concentrating her activities in the core has immediate access to

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This paper was presented at the recent S.P.I. Reinforced Plastics meeting in Chicago.

the entrances to the house and can easily supervise all the activities in the wings without having to move far from the central core area. The living functions are separated from each other in the four wings but are readily accessible to each other as necessary.

The cross-shaped plan leads to the idea of a small, compact foundation concentrated under the central core of the house with the four wings cantilevered from it. This considerably simplifies the foundation and, at the same time, makes the house adaptable to a wide variety of irregular sites because the foundation is small and compact. The fact that the cantilevers could be formed in a relatively few, large molded sections at the same time emphasizes the ability of plastics to be formed and molded to meet the structural and use requirements of the house rather than being built of a multiplicity of small pieces as is usually the custom in house construction.

The major portions of the house, therefore, consist of a central core and four wings. The core includes a floor over the foundation section, four columns, and a roof and ceiling section. Because shipping restrictions require that dimensions at least in one direction be held down to 8 feet and because each of the sections of the house is 16 feet square, it follows that the portions of the core must be either two pieces 8 feet by 16 feet for the floor and similarly for the ceiling and roof, or must be four pieces 8 feet square.

Shipping restrictions similarly dictate that each wing consist of two floor and two roof sections each 8 feet wide by 16 feet long. The floor sections are hollow girders consisting of an outer molded portion and an inner flat section. The outer molded shell extends from the foundation outward and upward to the half height of the end wall; the inner section consists of a flat floor sandwich capable of carrying the floor load. Similarly, the roof outer shell, which is identical with the floor outer shell, extends from the central core section outward and downward to the half wall height, and the ceiling section consists of a curved panel extending from the central core area out and downward to the half wall height. Two floor sections and two roof sections constitute the entire structure of each wing. The sides of the wings are non-structural and, consequently, can be transparent or partially transparent and partially opaque as may be desirable for the living quarters contained in any particular wing.

Engineering Design Problems

As is true of any structure, whether made of plastics or other materials, the engineering design approach to the house consists first of all of an analysis of the forces to which the house is subjected and the resulting stresses induced in the structure of the house and, secondly, a selection of materials and allowable stresses in those materials to meet the imposed forces and stresses.

In the design of this house, strength had to be considered both from the standpoint of short-time loads such as wind, and long-time loads such as equipment and the dead weight of the house itself. Equally important in this house with its long cantilevers was design for stiffness. The structure had to be sufficiently stiff and unyielding to give a comfortable feeling of solidity. Coupled with this was the problem of possible creep and continuing deformation under long-continued loads. All of these entered into the selection of working stresses as well as into the selection of materials having sufficiently high moduli of elasticity to provide the necessary stiffness to the structure.

Another factor entering into the design of any structure is the presence of concentration of stress which may be relieved by localized yielding with consequent redistribution of stresses into the surrounding material. Materials like structural steel are capable of such yielding and redistribution of stress. Reinforced plastics, on the other hand, especially those reinforced with glass fiber, do not yield appreciably before failure; consequently, it is not possible to count upon much yielding and redistribution of stress at points of concentration and, therefore, the stress intensities must be kept relatively low and the analysis for stress must be as exact as possible to unearth where points of concentrations may occur.

Major Forces

The major forces to be withstood by the house include first of all the dead load or weight of the structure itself; secondly, a variety of live loads including occupancy, wind, snow, and earthquake; and third, temperature stresses set up by the sun beating down upon parts of the structure.

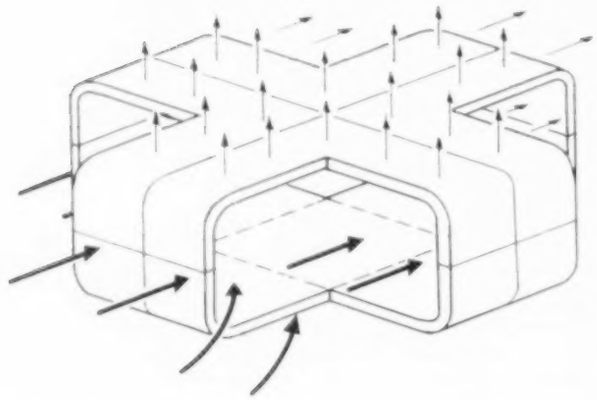
Dead. Because of the design, the dead loads on this house are reasonably uniform and symmetrically distributed. The weight of each wing is very much the same as the weight of any other wing. Any heavy equipment such as mechanical equipment and plumbing is all concentrated in the central core. By utilizing sandwiches and curved sections which are inherently stiff and resistant to buckling, fairly light-weight construction is achievable and the floor and roof sections of the wings are each found to average approximately 10 pounds per square foot. The weight of the floor core section including floor and mechanical equipment is approximately 15 pounds per square foot. The roof of the core section, like the wing sections, is approximately 10 pounds per square foot.

Live. Live loads occasioned by the occupancy and by furniture must be analyzed for two types of conditions. First, it must be assumed that the full live load at some time or other is distributed over the entire structure. In that case, the live load is at a maximum, but it is uniformly and symmetrically distributed like the dead loads. It therefore causes no tendency for the house to overturn. The second analysis requires the assumption that the live load may be found only in certain portions of the house and that, consequently, various degrees of overturning may be found because of uneven distribution. These loads are assumed to be distributed over the floor section, therefore, in various ways to determine the design conditions. They may include live load in one, two, three or four wings, live load in the core section only, or various combinations of the foregoing.

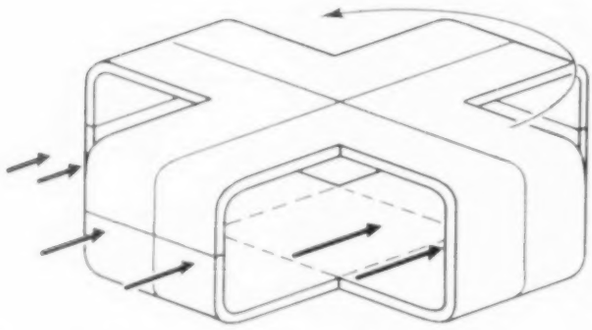
Wind. Wind loads depend upon the section of the country in which the house is expected to be built. The demonstration house is to be built in the California area where the Santa Ana winds reach velocities in the vicinity of 90 miles per hour. The wind, therefore, must be analyzed first of all for sidewise thrust against the side of the house on which the wind is blowing as well as a partial vacuum on the leeward side of the house, both of which tend to cause displacement and overturning. Because the roof is flat, winds blowing over the roof tend to lift the house. The wind might likewise get under any one of the projecting wings and cause an upward lifting tendency equal to twice the intensity of thrust on the side walls of the house. Furthermore, because the house may be partially protected, wind intensities may be greater on one wing, for example, than on another and, as a consequence, tend to cause a twisting or rotation of the house.

Snow. Although the demonstration house is not to be built in an area where snow loads are important, in the

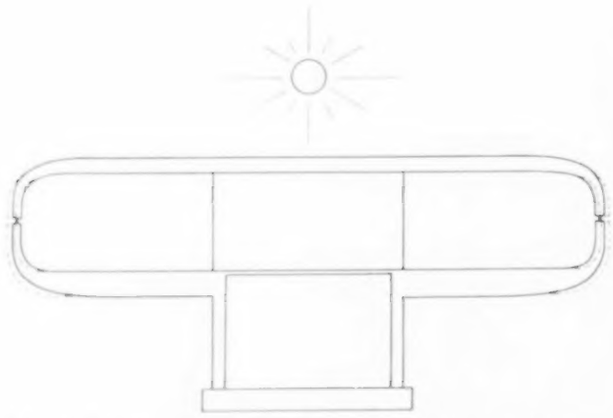
Effects of Wind and Sun



Wind tends to lift house and tilt it on the foundation



Force of wind may act to give a twisting motion.



Heat of the sun causes unequal expansions and thermal stresses.

complete analysis snow must be taken into account. This is a distributed load over the entire roof and this distributed load may be combined with any combination of internal live load. However, it is not to be expected that full snow load will exist at the same time that high wind velocities are encountered.

Earthquake. Earthquake loads are caused by horizontal accelerations of the earth and, consequently, induce horizontal thrusts on the structure which, in turn, are proportional to the mass of the building. Various empirical formulas have been developed for earthquake thrusts. Because this house is to be built in what is known as a Zone 3 earthquake area, it must be designed for maximum horizontal thrust tending to cause displacement and overturning. The horizontal thrust due to earthquake is an additional horizontal force which must be combined with the wind load because it is possible that earthquakes and high winds may occur at the same instant.

Sun. The hot sun beating down on this house can be expected to cause the roof section to become hotter than the rest of the house. Because the house is to be air conditioned, the internal temperature will be maintained at approximately 70 F, whereas it is estimated that the roof surface may easily rise one hundred degrees above the inside temperature. The floor section can be expected to rise only a small amount in temperature. As a matter of fact, the worst condition prevails when the floor section is assumed to remain at 70 F whereas the roof changes to 170 F.

Thermal Expansion

Plastics materials including reinforced plastics have relatively high coefficients of thermal expansion, as compared with other construction materials including metals, concrete and wood. Furthermore, in this house in contrast to most house construction, a few individual large units are tightly fastened together and, consequently, expansion can occur over the entire 48-foot length of a combination of two wings plus the central section of the house. Because the external surface of the roof section tends to expand whereas the internal ceiling section does not expand because it remains at room temperature, there is a tendency for the roof sections to thrust outward, downward, and to curl inward at the outward mid-wall height. This, in turn, throws a horizontal and downward force upon the floor section where it meets the roof section at the mid-wall height. The result is a combination of thrusts and bending movements set up in the roof and floor sections which must be analyzed and allowed for. Furthermore, if the house is partially shaded as it may be by trees, it is possible for one wing, for example, to reach the maximum temperature whereas the opposite wing is at a lower temperature. This sets up unbalanced expansion forces in the roof panels which may tend to cause twisting in parts of the house. All of this must be allowed for in the analysis of thrusts and forces within the structure, and the structure made adequate to withstand them without undue distortion or deformation.

General Features of the Structure

To achieve the maximum in stiffness and strength with a minimum amount of relatively expensive plastics materials, it was decided that the wings should be made continuous with the central core at the floor, ceiling, and roof. This is analogous to the construction of wings on aircraft which carry through in one continuous structure from one side of the fuselage to the other. Furthermore, in order to keep the columns as small and inconspicuous as possible, highly desirable from the architectural point, it was necessary to design them as slender members essentially pinned at the ends so that they could not be subjected to bending. This, therefore, meant that the floor sections had to be pinned to the roof sections at the half-story outboard ends in such a way that horizontal and vertical thrusts could be transmitted without inducing bending in the joint. Consequently, floor and

roof sections were designed as large hollow girders with their upper and lower surfaces subjected to longitudinal tension or compression, depending upon the magnitude and the direction of the loads imposed. The central core section had to be designed for thrusts carried through it in both directions; that is to say, from each pair of opposite wings. In addition, the roof shell had to be designed for transverse bending because of snow loads and the floor similarly had to be designed for transverse bending because of floor loads. In the floor of the central core such bending occurs simultaneously in both directions together with the direct tensile and compressive forces set up by the thrusts from the outboard floor and roof sections.

The construction of the roof calls, in addition, for four peripheral or spandrel beams to which the outboard roof sections are fastened and to which the central core ceiling and roof sections are similarly fastened. In the case of the central core floor, the concrete foundation wall takes the place of such peripheral or spandrel beams but it must be reinforced to resist the thrusts from the outboard wing sections transmitting their loads into the central core section.

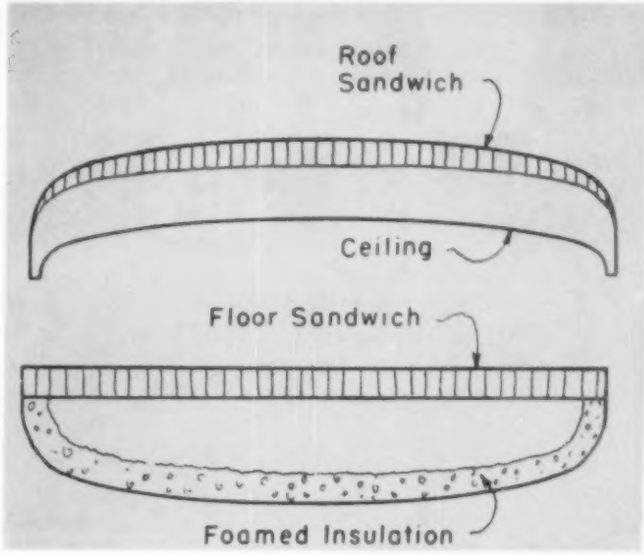
With these analyses completed, it was next necessary to determine allowable stresses and the materials to be employed. The next sections of this report describe in somewhat greater detail the stress analysis, the materials chosen to resist the stresses, and the results of loading tests on a test bent.

Materials Considerations

It is apparent that the architectural design of the house imposes some severe requirements upon the materials to be used in its construction. Because of the large sizes and shapes of the structural units chosen, a hand layup, non-pressure method of fabrication was the only relatively economical process possible. This, and the need for maximum stiffness because of the cantilever action in the design, led to a study of glass fabric reinforced polyesters from the point of view of mechanical and physical properties, raw material costs and fabricating costs and difficulties. The preliminary engineering design revealed that a modulus of elasticity of less than 2×10^6 psi would incur penalities with respect to the weight of the structure, thickness of laminates and fabricating operations, hence a modulus **E** = 2×10^6 psi was chosen as the minimum acceptable **E** and was used by the structural designer in his design calculations.

Initially, a laminate of approximately 55 percent glass content with 181 fabric reinforcement was chosen for investigation. Panels fabricated by vacuum bag techniques under shop conditions with a wet layup possessed tensile, compressive and flexural properties well above the minima. With an eye toward economy, numerous combinations of 181 fabric and 1½ oz. mat were investigated but all proved to be somewhat marginal with respect to both strength and quality variations, consequently the first test bent, a small floor section, was fabricated with 181 cloth completely. This included the outer shell and both faces of the floor sandwich. It resulted in a structural unit of exceptional integrity which passed the qualification tests with complete satisfaction. Unfortunately, however, the fabrication of the first, full-scale bent indicated that extremely severe handling difficulties existed in making a large layup of 30 plies of 181 cloth, involving curvature of section, corners and the like, hence this weave had to be abandoned. In its stead, careful consideration was given to woven roving fabrics and a pattern known as HG56 was selected. Test panels of this material were fabricated to the proper

Details of Construction



thickness under production shop conditions and the strength properties determined. It was immediately apparent that the tensile and flexural properties easily exceeded the minima; in compression, however, both strength and modulus values were deficient. To remedy this, a number of combinations of woven roving cloth and other fabrics and mats were explored. None of these showed appreciable improvements in their compressive properties over the rove cloth alone. Since compelling economic and fabricating advantages were associated with the use of the rove cloth, it was decided to take the properties available from it and restudy the structural analysis to assess the effects of the lower compressive properties. As might be expected, the principal consequences were:

1. Shifts in the neutral axis location of some sandwich and box sections in flexure.
2. Modifications in laminate thickness at certain points in the structure.
3. Minor redesign of mechanical connections where bolt bearing data indicated such was needed.

A second bent, composed of roof and ceiling shells, was constructed with the rove cloth reinforcement and subjected to the full scale tests described below. Its performance in these was considered satisfactory and therefore the remainder of the structural shells will be so fabricated.

Loading Tests

The unusual character of the structural bent, in terms of the shape and the material of which it was made, recommended that full scale tests be conducted upon it. The structural analysis had indicated which loading conditions would be most severe and the stresses and deflections to be expected under these conditions. As a consequence an extensive and carefully executed testing program was performed on the two previously mentioned bents; the upper rove-cloth one composed of roof and ceiling surfaces and the lower 181-cloth one composed of the floor sandwich and exterior skin. To do this it was necessary to construct a framework of steel, concrete and wooden members designed to simulate the rigidity of the actual house core.

Initially the lower bent of 181 fabric reinforcement

(Please turn to Page 61)

MOLDING CYCLES

Edited by Louis Paggi, *E. I. du Pont de Nemours & Co., Inc.*

Nozzle Design

Louis Paggi

SINCE the early days of injection molding, nozzles of many designs have been offered to the molder. Many of these nozzles have been designed to do specific jobs, as for example, ball check nozzles, color dispersion nozzles, pin point nozzles, etc. Still others have been designed to handle certain plastics or for specific injection molding machines.

No doubt many have felt that the average molding operation can be conducted with an all-purpose nozzle with little emphasis on the importance of design. While this may be true for a few applications where quality of the parts produced is relatively unimportant, it will usually be found that a nozzle having good design features will materially assist in reducing the number of problems encountered during the molding operation. It is certain that no single nozzle can do the best job for every conceivable application.

To arrive at a satisfactory design for a nozzle is not difficult if one first analyzes its basic function. Simply defined, the nozzle may be considered a tube used to convey molten plastic from the plastifying cylinder to the mold. With this in mind, there are several requirements necessary for good nozzle design among which are:

1. **Ability to control the temperature.**
   Numerous surface problems such as blisters, flow marks, splay marks, etc. often result when the nozzle is too hot, too cold, or non-uniformly heated. The nozzle should therefore be of sufficient length to accommodate a heating band or bands which will distribute heat uniformly over the entire surface or, depending on material molded, short enough to be accurately controlled by the front zone of the cylinder.

2. **A minimum of pressure loss during flow.**
   Narrow bore nozzles of excessive length often make it necessary to overheat the material in order to permit passage through the bore in a sufficiently short time. Back pressure generated during flow should be higher within the mold than at the nozzle. Failure to accomplish this will result in unbalanced filling of the mold, dimensional problems, and surface or internal defects. A good check for excessive pressure loss at the nozzle is to take an air shot between regularly timed cycles with the cylinder at normal temperature. If the ram does not move appreciably faster during the air shot than when molding, the bore of the nozzle is too small.

3. **A minimum of by-passing of material.**
   By-passed material in the nozzle may slowly degrade and then enter the flow stream, with the result that molded parts may suffer in quality. Because of the friction generated between the surface of the nozzle bore and the flowing plastic, the melt stream will flow at a faster rate at the center than it will at the periphery. It may then be stated that all nozzles, regardless of design, will permit by-passing of a certain amount of material. To what extent this occurs will depend on several factors, including the temperature and viscosity of the melt as well as the design of the nozzle bore. The design of the profile of the nozzle is the most important consideration in extent of by-passing. Straight bore nozzles flush-out more efficiently, while dual diameter bores with a considerable step-down between diameters (Figure 1) are the least efficient.
   However, dual-diameter bores are absolutely necessary for long nozzles, especially if the bore at the tip is required to be small. The tendency of material to be by-passed may be greatly reduced if the flow at the junction of the two bores is more streamlined, or the difference in the diameters of the two bores is reduced as shown by the dotted line in Figure 1.

4. **Retain a low inventory of material.**
   Because of the relatively small amount of steel in a nozzle, it will respond quickly to changes

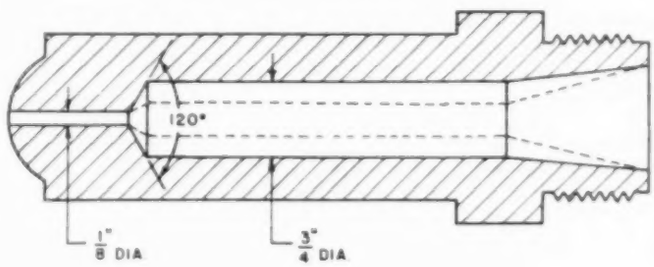


Figure 1. Dual diameter bore nozzle.

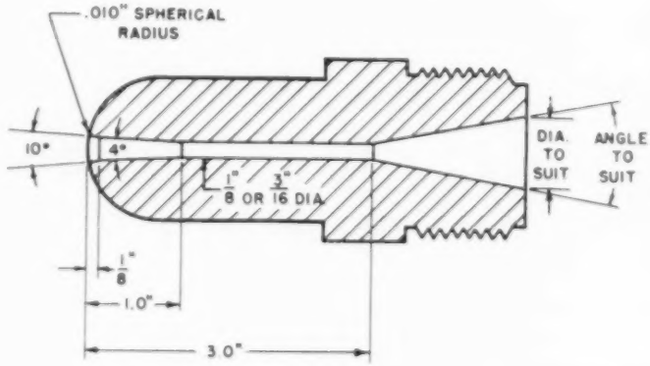


Figure 2. Improved design general purpose nozzle.

in temperature. This may result in an appreciable variation in temperature of material within small areas of the nozzle. With this condition, nozzles holding a considerable quantity of material in inventory may result in numerous problems with dimensions and quality of the moldings as well as poor mold performance. If a good portion of the shot is taken from material stored within the nozzle, the control of flow and temperature at the nozzle becomes critical. If on the other hand the amount of material held by the nozzle is no more than barely necessary to fill the sprue, the nozzle control is not as critical.

5. **Ruggedness with simplicity.** The nozzle should be designed and built to stand up under the relatively harsh treatment which accompanies normal use. For example, a $\frac{1}{2}$ inch radius at the tip of the nozzle is slightly more time consuming to machine than a $\frac{3}{4}$ inch radius, yet the $\frac{3}{4}$ inch radius will not be as easily damaged as a $\frac{1}{2}$ inch radius nozzle. A large number of molds are still being made with $\frac{1}{2}$ inch radius bushings, requiring $\frac{1}{2}$ inch radius nozzles. This is done in the belief that a small radius nozzle will seal better at the sprue. Actually no problems with sealing are encountered even with flat tipped nozzles, provided they are in good condition.

   The nozzle should not be too hard, leading to a tendency to crack easily or to damage the threads or seat of the adapter, nor should it be soft enough to crush easily at the junction with the sprue bushing. A hardness in the neighborhood of Rockwell C45 has been found to be satisfactory.

The nozzle shown in Figure 2 was designed for general purpose use in consideration of the factors discussed above. It is not aimed at eliminating the need for special nozzles. It will be noted that the minimum recommended bore for this length of nozzle is 1/8 inch diameter. The .010 inch spherical radius at the periphery of the bore at the tip is designed to eliminate the sharp edge which might otherwise result in notching and breaking the hardened material at the junction to the sprue. The 10° included angle will permit extraction of chilled material from the nozzle with greater ease. The reduction of angle to 4° included for the next 7/8 inch of the reverse taper is to minimize the increase of bore size at the tip. The straight bore section is designed for better flush-out and to reduce the quantity of material in inventory in the nozzle. Properly operated and in good condition, this nozzle eliminates the need for a cold-slug well in the mold.

SPEAKING OF EXTRUSION

Edited by R. D. Sackett
Technical Service Associate
Monsanto Chemical Company
Springfield, Massachusetts

The Mixing Torpedo

F. H. Collins
The Dow Chemical Co.

AT THE ADVENT of polystyrene extrusion, the screws used were those developed by the rubber industry. Although these screws were sufficient for the needs of the rubber industry, they proved quite inadequate for the extrusion of polystyrene.

In the course of developments, a screw utilizing a smooth torpedo was designed. This screw, having closer clearance with the cylinder wall, lessened the pulsating tendencies of the extruder and exhibited improved mixing characteristics However, the styrere was still forwarded to the die non-homogeneous in terms of heat and viscosity.

With the demand for closer tolerances in the extrusion of profiles and sheet, the single mixing torpedo[3] was developed. This torpedo is helically spiral fluted with smooth relieved radial grooves. (The flutes are segments of a circle slightly less than half as deep they are wide.) It is capable of forwarding a thermoplastic at good rates with a high degree of mixing. By the action of this torpedo, the material is forwarded to the die in a well-mixed, homogeneous form.

The design factors which bring this about are as follows. The thermoplastic is forwarded to the torpedo by a constant root, decreasing pitch worm screw. In this portion of screw, the thermoplastic is melted by frictional and external cylinder heat. By proper design, the efficiency of the mixing torpedo is equalized to the efficiency of the forwarding portion of the screw. Therefore, as the molten thermoplastic is forwarded to the torpedo, it is carried on by the torpedo. This is in contrast to the smooth torpedo past which the forwarding worm had to force the molten resin. This resulted in excessively high back pressures, low efficiency, and in turn, low production rates.

With the mixing torpedo, the thermoplastic is rolled and forwarded in the helical spiral flutes by the rotation of the screw. Being rolled in the flutes, all the plastic is brought in contact with the cylinder wall. Thus a more uniformly heated plastic is realized. Frictional heat is generated within the plastic by this rolling action, and to a lesser degree by the compounding action obtained by the smearing or scraping action between the flute lands and cylinder wall. As

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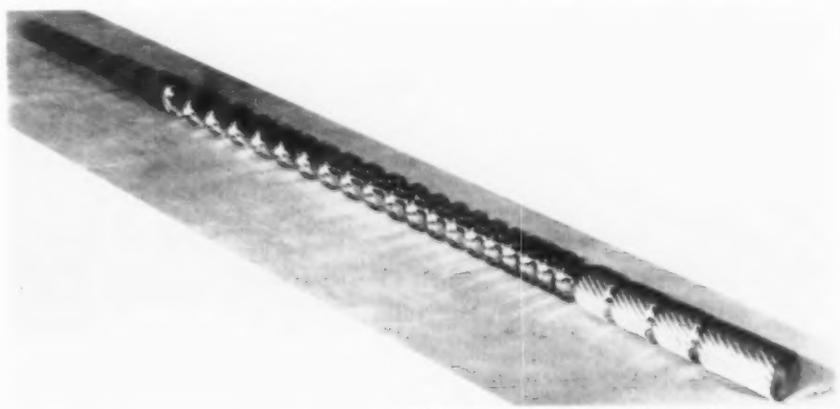

(photo courtesy of National Rubber Machinery Co.)
The single mixing torpedo.

Thin wall clear polystyrene containers are formed in this mold of CRUCIBLE CSM 2. Mold Builder: Standard Tool Company, Leominster, Mass.

they picked ultrasonically inspected

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FOR HIGHER FINISH . . . LONGER MOLD LIFE – It takes a highly polished and dimensionally accurate mold to form clear styrene into these thin walled containers. And, because production-runs go into the millions, the mold steel has to be long lasting. Both are good reasons why CRUCIBLE CSM 2 was selected.

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"The objects of the Society shall be to promote in all lawful ways the Arts, Sciences, and Engineering Practices and Standards connected with the utilization of plastics."

ACTIONS and REACTIONS

Excerpts—First Quarter National Council Meeting
April 4, 1957 Statler Hotel, New York City

Proposed: A Plastics Institute

First business of the year

Past President Jerome L. Formo, Plastics Institute Committee Chairman, reported that the purposes of the Institute are:

1. Basic research for plastics industry which may be of a type not commonly undertaken by individual companies.
2. Education of research engineers as a result of sponsoring the above research.
3. Dissemination of information by means of a well equipped library and, possibly, research publications.

Chairman Formo indicated that reactions to a Plastics Institute are very favorable and he plans to have the Institute study complete for submitting to the January 1958 meeting for action.

Another Section of SPE!

National Council approved a petition for charter for another geographical section of SPE to be known by the name of Rocky Mountain Section. It's officers are: Mr. Oscar B. Yorker—President, Mr. Paul L. Barrick—Vice President, Mr. J. Ellis Chanely—Secretary, and Mr. Raymond L. Millard—Treasurer.

In Gear For Next Year

Your National Council approved President Simmons' Committee Chairman appointments for 1957, 1958 fiscal year. Names will appear in the Roster of the June issue.

Executive Committee Change

Mr. George W. Martin of Western New England appointed to the Executive Committee to replace Dr. Norman A. Skow of Philadelphia. George is to be Administrator of the Professional Activities Groups. Dr. Skow will act as assistant Administrator of PAG.

Change By-Laws?

Mr. Wayne I. Pribble was named Chairman of the Constitution and By-Laws Committee replacing Mr. George W. Martin. Wayne is making a complete study and condensation of all the actions by the past Council and plans to have the thread unraveled and rewoven to submit to the January 1958 Council. IN THE MEANTIME at the June Council Meeting your Council will vote the final vote on revision to B-11, B-13, B-16 which in essence are: that all members (foreign and domestic) pay the same dues; that the foreign members would still not have to pay initiation fees except in the case of a new section which would receive all of the initiation fees for the first 24 months of its charter.

Sections To Broaden Journal Distribution

Journal to be made available by Sections—Executive Committee recommendation was read: that the geographical sections of SPE be permitted to subscribe to the SPE Journal (at what would be the member's rate) now $4.00 for the purpose of making the Journal available to appropriate institutions.

Target Met

One of Administrator Gossett's committees reached target as outlined by President Simmons in the April Journal:

1. Procedure Manual for ANTEC and RETEC: Frank Martin, Chairman of Meetings Committee, submitted first portion of the revised manual and received approval.
2. Manual for Authors of Technical Papers: John Picard, Detroit Section, presented manuscript for author's guide and received approval from your Council.

RETEC, What is That?

RETEC is a section sponsored Regional Technical Conference. There were two bid for at this meeting and another in the making. Southern California is bidding for RETEC on "Plastics in Air Born Electronics" for November, 1957. Clevelard-Akron bids for "Polyethylenes—Properties and Uses" October 17, 1957. Upper Mid West bid for an "Isocyanates Symposium" October 8, 1957.

Councilman From Connecticut

Mr. David Mersey—reported on his section's work with high school students in an effort to interest them in the field of Plastics Engineering. Demand for education in Plastics Engineering must come from the students. When it does, there will be no difficulty in interesting colleges in establishing courses leading to B.S. degrees in Plastics Engineering. Jules Lindau, Education Committee, supports this view.

Growth

1947	1957
Journal—17 pages	70 pages
ANTEC—700 in attendance	1900 in attendance
Members—1800	5100
Sections—17	37

NEW—Plastics Institute—Educational Film—Publishing First Volume in a series of Technical Volumes—11 active Professional Activities Groups—700 page ANTEC Preprints—all of this calling for the approval of a quarter of a million dollar budget.

Growth of you, by you, and for you!

Jas. R. Davidson
Executive Secretary

Encapsulation Committee Report

Cooperation With Other Technical Groups

Mr. Philip J. Franklin of Diamond Ordnance Fuze Labs reports that copies of the papers presented at their January 1956 Casting Resin Symposium can possibly be obtained from Mr. Ronald K. Jurgen, Editor, Electronic Equipment, 172 So. Broadway, White Plains, N. Y. for a nominal fee. Also, Mr. Franklin said that some copies are still available upon request to him at Ordnance Corps, Diamond Ordnance Fuze Laboratories, Washington 25, D. C.

Mr. Don A. Hamilton, President, S.P.E. Southern California Section, has informed us that his group hopes to hold another symposium in November, 1957, on "Plastics in Air-Borne Electronics," which will embrace encapsulation subjects. We will be kept informed of progress on this symposium as it shapes up. The Southern California Section also informed us that copies of the papers presented at its November 1956 symposium are available at the National S.P.E. O__ce for $2.50 per copy.

Both Mr. Franklin and Mr. Hamilton expressed willingness to cooperate with our Committee on Encapsulation if we can become organized to the point of carrying out conferences or projects.

The New England Sections have planned a conference entitled "Plastics for Electronics" to be held on June 14, 1957 at Lowell Technological Institute. Papers of interest to our group will be presented there. Inquiries concerning this conference should be addressed to Ralph L. Mondano, Raytheon Manufacturing Co., Plastics-Research Division, Waltham 54, Massachusetts.

Persons interested in the SPE Encapsulation committee are invited to attend an informal meeting immediately before the Lowell Conference. Contact C. A. Harper, Air Arm Div., Westinghouse Electric, Corp., Baltimore, Md., for details.

Technical Discussion Items

One of the objectives of our Committee is to obtain a broad range of ideas on items which are of specific interest to members of our group. For this reason, the following items are submitted in the hope that comments, ideas, opinions, and solutions can be obtained on the subjects with which you have experience or knowledge. Specific data or reports are desired where this is possible.

1. Experiences in Reducing Dermatitis Problems.
2. Experiences on Reduction of Corona Problems.
3. Granulated Epoxy or Polyester Type Compounds for Compression or Transfer Molding.
4. Castable Materials Which Maintain Rigidity and Good Electrical Insulation Properties for High Temperature Applications.
5. Resin-Filler Electrical Insulating Compounds Which Have Thermal Coefficients of Expansion Close to Those of Aluminum and Steel.
6. Low Shrinkage, Resilient Compounds Which Will Not Crack in Fifty Thermal Cycles Per MIL-E-5272A, Using Hex Bar Samples.
7. Foam or Low Density Compounds Which Maintain Good Strength and Electrical Insulation When Tested per MIL-E-5272A; Heat Dissipation Data from Embedded Subminiature Tubes Also Desired.
8. Strength, Electrical Insulation, and Environmental Resistance Comparisons of Low Viscosity and High Viscosity Commercial Liquid Epoxy Resins.
9. Use of Fillers to Control Thermal Conductivity, Shrinkage, and Cracking Tendencies of Reactive Resins.
10. Studies of Various Systems for Mixing, Metering, Proportioning and Dispensing Reactive Resins — Reliability and Efficiency of Such Systems.

In order to maintain close contact within our group, communications on any or all of the above subjects are requested by May 15, 1957. All comments will be published in the next general communication of this Committee. Included in your correspondence should be listings of any other subjects on which you would like group comments, as well as any new ideas which you feel the Committee on Encapsulation should undertake. Depending on participation, it may be possible to delegate task groups for the furtherance of Committee objectives, or to hold Committee meetings, discussion groups, or conferences.

SPEaking of Extrusion. . .

(Continued from Page 43)

the thermoplastic is smeared over the flute lands, it is heated both by contact with the cylinder wall and by the frictional heat generated by the smearing action.

Lower cylinder temperatures are realized with the mixing torpedo than with the smooth torpedo. High cylinder temperatures were necessary with the smooth torpedo in order for this heat to penetrate that plastic in contact with the torpedo. The mixing torpedo's action brings all plastic in contact with the cylinder wall, and heat penetration and higher cylinder temperatures are no longer necessary.

The multiple fluting on the torpedo divides the flow of the molten plastic from the screw flight into many smaller streams, thus greatly reducing the inherent pulsations which otherwise occur with the use of more conventional screws and torpedo sections.

The recommended effective length of screws utilizing a single mixing torpedo is 18 to 21 diameters. That is, a 4.5 inch diameter screw would be 81 to 95 inches long. Of this length, the mixing torpedo is 4.5 to 5 diameters long. Less than this may result in insufficient mixing; more might result in excessive frictional heat. These lengths are considered to be optimum for a balance between production rates and homogeneity of the molten plastic.

Experience has found the constant root, decreasing pitch forwarding worm to perform quite satisfactorily with the mixing torpedo. Late developments indicate that a constant pitch, constant root feed screw may also prove satisfactory for use with the single mixing torpedo, thereby reducing the cost of the screws.

Most thermoplastics exhibit an inherent tendency to return to the shape to which they have been forced to conform. This tendency is called plastic memory. In extrusion, with more conventional screws and torpedo sections, the plastic is carried along in the root area between the flight of the forwarding worm and is conformed to this spiral shape. Upon being emitted from the die, the plastic tends to return to the shape to which it was conformed as it moved along the screw. Warpage of the extruded end product may result from this root memory.

The compounding action administered to the plastic by the single mixing torpedo eliminates, for all practical purposes, the root memory induced into the plastic in the worm portion of the screw. The relieved radial grooves along the torpedo allow for intermixing of the plastic, minimizing any memory which may tend to develop in the plastic as it passes through the torpedo flutes.

The single mixing torpedo was developed primarily for the extrusion of ethyl cellulose and polystyrene, both general purpose and high impact, and has found extensive use in the fabrication of these polymers. Several fabricators have also found the mixing torpedo to perform well in polyethylene extrusion. With vinyls, the mixing action of the torpedo is too severe, oft times resulting in degradation of the compound.

Precision of the fabricated plastic product is, among other things, dependent upon the homogeneity of heat and viscosity of the polymer and absence of pulsations. The single mixing torpedo is capable of these functions and has assisted numerous fabricators in producing plastic profiles and sheet within the quality standards of the industry.

Industrial Literature

Ethylene Spray

A newly designed and enlarged eight-page equipment and semi-finished component section of its general catalog has just been issued by the American Agile Corporation, Maple Heights (Cleveland), Ohio.

Of particular interest is a page devoted to the company's recently introduced mobile dual purpose thermoplastic spray and fluidizing unit. Known as the Mark III, the unit is easily rolled to the point of use for fast, economical and flexible operations.

Copies may be obtained, without charge, from the American Agile Corporation, P. O. Box 168, Bedford, Ohio.

Lester-Phoenix

Lester-Phoenix, Incorporated announces new Bulletin No. 202. Colorful brochure describes in detail all the features of Lester injection molding machines. Literature contains a complete chart of specifications of all Lester models, a list of Lester users, stories of typical installations, and cutaway views of basic components.

Write for your copy: Lester-Phoenix, Inc., Dept. N-55, 2711 Church Avenue, Cleveland 13, Ohio.

New Epoxy

A new high viscosity opaque dip or brush coating compound possessing outstanding adhesion to metals and plastics is now available for manufacturers of electrical components and for application as a resilient coating. Identified by a light blue color, this new compound has been prepared from a resilient epoxy resin (Epocast 19-B) and a special hardener. No solvents are present.

For additional information request bulletin EP-57-7 from Furane Plastics, Incorporated, Los Angeles, California.

Steel Fastenings

A brand new catalog (#56-A) just issued by Star Stainless Screw Company lists many new sizes and types, adds a number of new products, such as hinges and screw machine products, as well as detailing several pages of helpful data. In all, the catalog covers well over 7,000 items.

Copies of the new Star catalog are available from Star Stainless Screw Company, 655 Union Boulevard, Paterson 2, New Jersey.

Wire Resistors

Tubular and flat power wire wound resistors. Comprehensive data on construction, characteristics, coating, winding, insulation identification, mechanical strength, terminals and brackets—detailed charts and graphs. 12 pages.

Write International Resistance Company, 401 North Broad Street, Philadelphia 8, Pennsylvania, for Bulletin C-1b.

Industrial Designer

"How to work with the Industrial Designer" is the title of a new brochure issued as a service to manufacturers and advertising agencies. Published by Leotta & Parcher, Conshohocken (Pa.) industrial design firm, the brochure gives eight suggestions which will enable manufacturers to make better use of outside product design services or use outside designers to cooperate with their own design department. The brochure is also available to advertising agencies since many agencies are called into product design conferences by their clients. Copies may be obtained by writing to Harry H. Foster, Director of Design Promotion, Leotta & Parcher, 303 Harry Street, Conshohocken, Pa.

MEETINGS

New England RETEC

"Plastics in Electronics"

June 14, 1957, an SPE Regional Technical conference on Plastics in Electronics will be sponsored by the New England Sections of SPE at the Lowell Institute. For program and details write to Ralph Mondano, Raytheon Mfg. Co., Plastics Research Div., Waltham 54, Massachusetts.

Applied Chemistry

The 30th International Congress for Applied Chemistry will meet September 17-24 in Athens, Greece. The President of the Congress extends cordial invitations to members of SPE. They invite participation from all countries. Interested persons should write for information to Prof. A. Delyannis, L'Union des Chimistes Hellenes, 10 Rue Caningos, Athens, Greece.

Design Engineering

The 1957 Design Engineering conference is slated for May 20-22 in New York City, sponsored by A.S.M.E. Write to A.S.M.E., 29 West 39th St., New York 18, New York.

Midwest SPI

A two-day SPI Midwest Plastics Conference, combining business meetings with golf and other recreational activities, will be held June 13 and 14, 1957 at the Arlington Hotel, Hot Springs National Park, Arkansas, under sponsorship of the Midwest Section, The Society of the Plastics Industry, Inc.

"How to Exist in Today's Market" has been selected as the theme of the June meeting.

"Engineering Institute"

An Engineering Institute for Plastics will be held by the University of Wisconsin at Madison, Wisconsin on May 13th and 14th. Subject of the Institute will be "Plastic Laminates" and "Reinforced Plastics."

"Standard and Special Grades of Industrial Laminates," J. C. Pitzer, Formica Corp.

"Printed Circuitry," St. John Bain, Formica Corp.

"Saturating Papers for Decorative Laminating Applications," Carl D. Roess, Wrenn Paper Co.

"Printing and Decoration of Paper for Decorative Laminates," John Pollock, Fitchburg Paper Co.

"Manufacture and Application of High Pressure Decorative Laminates," Robert Boehme, St. Regis Paper Co.

"Some Thoughts on Plastic Laminates," Dr. Johan Bjorksten, Bjorksten Research Laboratories.

"Resins in General Use Today — How They are Used and Why," Charles H. Dugliss, American Cyanamid Co.

"Glass Fiber Reinforcements," C. E. Egan, Owens-Corning Fiberglas Corp.

"Practical Case Histories of Electrical and Mechanical Fiberglas Polyester Applications," Charles D. Jones, Structurlite Plastics Corp.

"Summary of Progress of Reinforced Plastics," J. E. Stokes, Bakelite Co.

Due to the size of facilities being used, attendance will be limited to 75. Those wishing to attend please make your reservations at once. A fee of $20.00 should accompany each application for enrollment. This fee will cover the cost of the course and materials but not the cost of room and meals.

NEWS of the industry

W. R. Grace Company Opens Main Offices

By I. R. Rubin

W. R. Grace & Company's Polymer Chemical Division opened its main offices and laboratories in Clifton, New Jersey, with an open house for members of the industry and the press.

Their semi-works plant for the production of high density polyethylene, under the Phillips license was completed in July of 1956. The $20,000,000, plant with an annual capacity of 50,000,000 lbs. of their GREX Polyethylene resin, will be on stream in the middle of 1957.

Mr. T. T. Miller, President of Polymer said, "We believe Clifton, New Jersey is an excellent location, because over 50% of the plastics fabricators in the country are located in a 300 mile radius. In addition we are establishing regional sales offices in other key centers throughout the country, such as, Chicago and Los Angeles. Also, New York area is an important market place for all plastic fabricators in the United States, and we expect to help them when they visit this section to meet with their own customers".

"Our service engineers, are developing new techniques for molding and extruding polyethylene in rigid materials, as well as film and sheet, most every day."

The laboratories are well equipped, containing automatic and conventional injection molding equipment, assorted extruders, milling equipment, complete testing equipment of all kinds, experimental polymerizing laboratories, chemical laboratories, product development areas and their own plastic library.

The laboratories and testing equipment of the W. R. Grace & Co.'s polymer division should be of value in solving some of the problems in the fabrication of high density linear polyethylene, and add to the growing fund of engineering knowledge.

Egan Expanding

Frank W. Egan & Company, manufacturers of plastics processing equipment, has announced plans to double the size of its Somerville, N.J., plant.

According to a company spokesman, contracts for the extensive addition have been signed with Milne & Markert, Inc. of Plainfield, N.J. Construction is expected to be completed by late summer. The new wing, which will provide an additional 16,000 square feet of floor space, will be used for the expansion of manufacturing and office facilities.

Frank W. Egan & Company was located in Bound Brook, N.J., until April 1955, when operations were transferred to the new Somerville facilities.

Dust Problem Solved

A hopper loader attachment which is said to solve the dust problem in the handling of dry-coloring materials has recently been placed on the market by C. H. Whitlock Associates, 21655 Coolidge Highway, Oak Park 37, Michigan.

The dry-coloring attachment is extremely simple. It consists of a round aluminum weldment which is attached to the end of the conveyor tube directly over the hopper and holds a conical shaped filter, the filter cone being so installed that the smaller end extends down into the throat of the hopper.

In operation, the filter cone is help loaded about half full of material. As the material is used, it drops through the bottom of the cone into the hopper throat and is replenished in the cone by the hopper loader. The upper part of the cone acts as a filter, collecting the dust on the inner surface. The filter cones are replaceable at small cost.

Plastic Blender

Kish Industries, Inc., 1301 Turner St., Lansing, Mich., today added an automatic plastic blender to its line of products.

Steven Kish, president of Kish Industries, said the product, called Ki-Pla-Blender, is in production and will be marketed by the company's nationwide sales organization.

Originated and engineered first by Kish, the blender was designed and created to end guesswork in the dispensing and use of epoxy plastic materials. Compact and portable, the dispenser weighs approximately 30 pounds. The price is $225 (FOB Lansing) with accessories and optional items available.

Automatic Oiler

After 2 years of development and exhaustive field tests a fully automatic oiler for pneumatic portable tools is now available.

The Carlson "Inject-O-Mist" was developed to protect and lubricate such portable pneumatic tools as air staplers, air wrenches, air screw drivers, air riveters, air strappers, air sealers, air nailers, air tapers, air drills and other air activated tools with air cylinders working on intermittent principle.

The inventors of this oiler through field test have cut down time on pneumatic portable tools by as much as 80% and increased tool efficiency on some tools by over 50%. The Carlson "Inject-O-Mist" is being manufactured by Carlson Products, Inc, 5309 North 24th Street, Omaha, Nebraska.

New Company

Fiber Glass Industries, Inc., has purchased the fiber glass and reinforced plastics operations of Bigelow-Sanford Carpet Company, Inc., according to joint announcement today. These operations are located at Amsterdam, New York, and employ about 100 persons.

Fiber Glass Industries, Inc., is a new organization, incorporated in New York and located in Amsterdam, and has no connection with Bigelow-Sanford. Its president is Ara T. Dildilian, former general manager of the fiber glass and reinforced plastics activities at Bigelow-Sanford. Roger B. Knowles, former manager of Bigelow-Sanford's reinforced plastics division, is vice president.

Double Drum Winder

Frank W. Egan & Co. of Somerville, N.J., has announced the development of a new double drum winder with provisions for making a flying transfer at speeds up to 1,000 feet per minute. Patent has been applied for.

A double drum surface winder produces a hard wound roll free from the troubles of telescoping. The slight variation in surface speed between the two winding drums causes a tightening effect. In this regard, it is preferable to a single drum surface winder (commonly referred to as a "Pope Reel"), although the latter unit has been more widely used owing to its capability of accomplishing a flying changeover.

Injection Machines

Practically unlimited varieties of small molded plastic products can now be developed and produced quicker, easier, with major cost-savings, by the new line of improved "Mini-Jector" Plastic Injection Molding Machines announced by Newbury Industries, Newbury, Ohio. Users report hundreds of dollars saved in tooling alone.

According to company president, W. O. Frohring, "Now, for under $1000, any company can be equipped with one of these machines, a mold blank and enough plastic material to start developing and producing perfectly formed products and parts." "Mini-Jector" prices start at $875 (¾ oz. cap.). Mold blanks cost as low at $37.50.

Silk Screen Colors

The Sullivan Chemicals Division of the Sullivan Varnish Company, 420 North Hart Street, Chicago 22, Illinois announces the addition of a line of silk screen colors to supplement its established line of spray colors and finishes. This firm specializes in decal lacquers, vinyl and acetate screenings, and screening for butyrate, polystyrene, acrylics. Complete prices, color cards and other information can be obtained by writing directly to them. They are also interested in setting up dealers for their new line throughout the United States and Canada.

3-Ms Buys Firm

Purchase of the KEL-F chemical manufacturing business from The M. W. Kellogg Company, a subsidiary of Pullman Incorporated, by Minnesota Mining & Manufacturing Co. was announced jointly by officials of the two firms today.

Officials of Minnesota Mining & Manufacturing Co. stated that negotiations have been completed for the Minnesota firm to take over the KEL-F manufacturing facilities adjacent to Kellogg's Jersey City steel fabricating plant and research laboratories.

Jacobs Relocation

The H. G. Jacobs Mfg. Co., Inc., of 159-167 Linwood Ave., Paterson 2, New Jersey have completed their plant relocation project and are in full production at their new plant. H. G. Jacobs, President and founder of this company, which manufactures plastic tool handles and other industrial items, says the final stage of fully air conditioning the plant is under way. A wholly owned subsidiary, Impacto Plastic, Inc. is also located at the same address.

Lawrence Sold

The Lawrence Process Company, Inc. of North Andover, Mass., manufacturer and processor of extruded plastics products, has been acquired by the Borden Company's Chemical Division, according to an announcement by Augustine R. Marusi, president of the Chemical Division. It will operate as a wholly owned subsidiary of the Borden Company.

Westchester Plastics

Westchester Plastics, Inc. announces that its new Color Blending Laboratory is now in operation. Designed to investigate problems in the development and control of exacting color shades, the fully staffed laboratory will insure the exact duplication of subsequent color orders received by Westchester.

Men In The News

Charles Proudfit

Charles W. Proudfit has been appointed to the position of Director of Sales of the newly created Resin Products Department of Celanese Corporation of America's Plastics Division, it has been announced by E. W. Ward, general sales manager. He will supervise sales of Celanese polyester resins and polyvinyl acetate emulsions used in the paint, textile, paper and other industries.

Mr. Proudfit, who lives in Pines Lake, New Jersey, comes to Celanese from a position of Sales Manager of the Hormann-Seitz Manufacturing Corporation of Newark, New Jersey, and has an extensive background in the sales of vinyl emulsions, polyester resins and drying oil products.

Prior to his last position, Mr. Proudfit had a number of years experience as a sales representative for polyester resins and vinyl emulsions for the Naugatuck Chemical Division of U. S. Rubber, market development work on drying oil products for Congoleum-Nairn and as a consultant on Chemical Markets for Frank C. Brown & Co., a consulting firm in New York City.

Thomas E. Wood

Appointment of Thomas E. Wood to the position of Director of Programming and Development was announced in March by Flick-Reedy Corporation, Melrose Park, Ill.

In the newly created post, Wood will direct employee and salesmen communications, conduct training programs for present and new employees, and help employees formulate and work toward a realistic career goal, according to Frank Flick, president.

Henry DeVore

Henry W. DeVore has been named director of Plaskon plastics and resins sales for Barrett Division, Allied Chemical & Dye Corp., New York, according to an announcement by T. J. Kinsella, president. He succeeds Carleton Ellis, Jr., who has resigned to accept an executive position in another field.

John Bachner

John J. Bachner has been elected president of Chicago Molded Products Corp., one of the largest plastics molding companies in the country, and a leading producer of melamine dinnerware as well as extruded plastic sheeting. Mr. Bachner, executive vice-president and general manager since 1954, succeeds the late Marcel F. Bachner who died February 21, 1957.

Alio Buselli

W. R. Grace & Co.'s Polymer Chemicals Division announced the appointment of Dr. Alio J. Buselli as Manager of Chemical Research at its Clifton, N. J. laboratories.

Standard Tool

Two additions to the firm's expanding sales force are announced by Lionel B. Kavanagh, president of Standard Tool Co., Leominster, Mass., supplier of mold components and other equipment for the plastics, rubber, and other industries since 1911. John F. Neuman will be based in Chicago to represent the concern in the Midwest. Milo Dellmann will cover the West Coast from headquarters in South Gate, Calif.

Mr. Kavanagh said that the two new representatives will work closely with Joseph P. Healey, whose affiliation with Standard Tool to assume the newly created post of sales engineer was recently disclosed. Mr. Healey will coordinate their efforts in providing technical assistance for efficient applications of stock and special molds, presses, cutters, beryllium cooper castings, and other items in the Standard Tool line.

William Fondiller

Mr. Jerome Taishoff, President, Mycalex Corporation of America announced the appointment of Dr. William Fondiller as technical consultant and special representative of Mycalex Corporation of America and associated companies.

Dr. Fondiller will act as a consultant on insulating materials, with special emphasis on the communications industries, and will have a leading part in the lecture and educational program maintained by Mycalex Corporation of America for the information of engineering groups all over the country.

Paul Conaway

Paul Conaway, formerly with Celanese Corporation of America, has joined the Foster Grant Company of Leominster, Massachusetts, as Central Representative of its Petrochemical Division.

Julian Rogers

W. R. Grace & Co.'s Polymer Chemicals Division has appointed Julian A. Rogers head of the Manufacturing Department of its high density polyethylene plant in Baton Rouge, La.

J. D. Proctor

J. D. Proctor, General Sales Manager of the Celluplastic Corporation, Newark, New Jersey, has been elected a Vice President of the Corporation, according to an announcement made by J. D. Giles, President.

Thomas Egan

Thomas J. Egan, formerly with Dow Chemical Co., has joined the Foster Grant Company of Leominster, Mass., as midwestern representative of its petrochemical division.

AROUND THE WORLD

FRANCE

INDUSTRIE des PLASTIQUES MODERNES

January, 1957

Abstracter: Hans Mayer

HIGH TENSION REINFORCEMENTS
—L. Blumental

The requirements of insulation materials in connection with electricity are enumerated and evaluated against the plastic materials employed for this purpose. The writer evaluates paper reinforced phenolics in this connection in all its phases from manufacture to actual tests. Later developments like glass reinforced epoxies are shortly mentioned.

PNEUMATIC CONDITIONING
—G. Janny

The shipments of electronic or electrical devices and of machinery which should not be exposed to shock can be greatly improved by forming air cushions between the packing case and contents of the shipment. It is described how these cushions should be designed and how the strength of the expected shock will have to be calculated in order to establish the proper amount of equalizing pressure required. The requirements for pressure in turn determine the thickness of the vinyl film to be used for the cushioning. This system lends itself for combinations with safeguarding against climatic conditions when necessary.

THE JUNCTION OF TUBING WITH BUILT IN RESISTORS

Thermoplastic fittings and tubings are molded with nickel alloy wire inserts which extend through the molding. Connections are made by placing the fittings together and connecting the extended wires. The wire is then connected to a 6 volt battery and the heat of the resistors welds the fittings into a closed system. The battery is then disconnected and the extensions are cut off. Since the wire is molded in, no metal is exposed inside of the system.

GERMANY

KUNSTSTOFFE

February, 1957

Abstracter: Anne Schwend

PLASTICS FOR FOODSTUFF PACKAGING
—L. Robinson-Goernhardt

Incited by the draft for a German Federal Republic Law on the use and handling of plastics for preservation and packaging of foodstuffs, U. S. literature by J. Lehman on the toxicity of chemicals in foods, drugs and cosmetics as well as other pertinent literature is reviewed and so presented as to give a picture of the situation on the world market. This article invites discussion of the problem and, in particular, stipulation of uniform investigation methods for the tracing of possible migrated plastics in foodstuffs.

THE PLASTICS INDUSTRY IN LATIN AMERICA
—G. B. Von Hartmann

A report on the economic situation of Latin American States under special consideration of prospects in exporting plastic compounds and ready articles to these countries.

INTERNATIONAL STANDARDIZATION OF PLASTICS

Report on the 6th convention of the Technical Committee of ISO/TC 61 Plastics in Den Haag/Netherlands between September 17 and 22, 1956.

A NEW METHOD OF MIXING AND COMPOUNDING OF PLASTICS IN ONE OPERATION
—Peter Pilz

To effect the same mixing degree as realizable in high-speed agitators for fluids it is important to produce highly effective shearing zones in the powdery plastics compound awaiting mixing. The same principles as applied in agitators help to accomplish this task: increase in circumferential speed of the mixing tool and formation of maximum speed gradients by arranging stationary elements in the immediate neighborhood of the rotating blade. The pre-requisite for such design—the possibility of treating the powdery material the same way as fluids—is guaranteed by blending in air. The small air cushion between compound and cover of the apparatus suffices for this purpose and is sucked into the compound through the rotor action. A detailed description of this mixer is completed by release of results of quantitative tests of the blending quality, the increase in degree of aeration by adding extremely fine compounds modifying the contact surfaces particle air and comparison tests with a mixing drum, which all speak in favour of this new mixer. The job of gelatinizing the compound is partly taken over by this new apparatus so that the forming machine is partly relieved.

DETERMINATION OF THE VOLATILITY AND MIGRATION OF SIMPLE AND HIGH MOLECULAR PLASTICIZERS
—A. Merz

ASTM D 1203-52 T and the proposed ISO standard "volatility of plasticizers from plastics" are discussed and compared with the air jet method. Several proposals have been condensed in DIN standard No. 53405 for the determination of the extent of migration from plasticized films, which is also discussed.

A NOVEL COATING MACHINE
—Heinz Devant

Coating machines incorporating several coating systems in horizontal tandem arrangement have many disadvantages due to inaccessibility, disadvantages which have now been overcome by designing and constructing a machine having a turnstile supported by a robust axis to make it shockproof and insensitive to oscillations. This turnstile holds four, and if

necessary even more stationary counter-tools to the knife, i. e. a rolling rubber belt, two steel rolls for air knife coating, a rubber and a steel roll for roll coating and a supporting knife. This revolving system is balanced out well so that it can be turned around even manually. The knife support is equipped with two different knives in order to permit changeover from rubber belt coating to coating on rubber or steel rolls or air knife coating. Auxiliary equipment for laminating or pneumatic take-off can be hooked to this novel machine.

EXPERIENCE IN USING MOLYBDENUM DI-SULFIDE LUBRICATING FILMS AND PLASTICS HOLDING MOLYBDENUM DISULFIDE—E. Escales

Experiences in the use and application of "Molykote" lubricants in dry, liquid and plastics-bound status are communicated.

FORMING OF RIGID PVC SHEETS—Heinz Oelze

A survey on the possibilities of forming rigid PVC sheets considering especially the different forming methods from the angle of best possible production of a certain shape of articles, suitable mold materials, cutting out of drawn articles and closing of deep-drawn packaging containers. This paper was presented at the convention of the Swedish Plastics Association in Stockholm in November 1956.

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KUNSTSTOFF-RUNDSCHAU

February, 1957

Abstracter: Leo Fischer

DOCUMENTATION —J. Hausmann

This article is a report on an "International Congress for Documentation of Applied Chemistry" held in London in Nov. 1955. The Congress discussed the great need for consolidation of translations, and catalogueing of technical literature, patents, publications, bulletins etc. for every industrial country. The following proposals were adopted:

1. Creation of a central documentary institute in each country to abstract all technical literature and establish standard nomenclature.
2. Looking into the possibility of using one language for all technical literature.
3. Forming of an international committee of experts and scientists to work out a uniform code for classification and indexing.

Reports were made by a number of countries on the status of documentation in their countries. The USA reported no central organization for documentation but extensive work is being done by private chemical companies, technical societies, Patent Office, universities and libraries. The Soviet Union reported a Documentary Institute employing hundreds of people which translates, abstracts, indexes and micro films 7000-8000 documents per month. UNESCO stated that one half the world's technical literature is now translated and indexed into Chinese and Russian. Germany seems to be far behind in this work except for the Plastic Institute which has excellent documentation on all plastic literature and patents of leading industrial countries. They publish a 50 page monthly bulletin with 400-500 references.

THE CHANGING MEANING OF THE TERM "E—" POLYESTER" —Walter Toeldte

To avoid confusion in terminology it is suggested to restrict the use of the word "Polyester" to such synthetic resins only whose macro molecular chain is built up by means of esterification. For high molecular weight polyesters the word polyplastic is suggested; where the molecular chain and structure is built up through esterification the term plastic is recommended. Polymers with diallyl phthalate are to be called allyl phthalate plastic.

PETROLEUM AND NATURAL GAS AS RAW MATERIALS FOR PLASTICS (CONTINUATION AND CONCLUSION) —Erich M. Bayer

The chemistry of cracking petroleum with a view to the plastic industry is further discussed as a continuation from a previous article. The author reveals that these articles are abstracted from a comprehensive book on the subject soon to be published in Italy and translated by Dr. Bayer.

The following groups are considered: butadiene, ethylene, propylene butane, and the aromatics. Plastic derivations from each group are given. Structural formulae and formulae of the derived plastics are also presented as well as flow sheets and a general outline of techniques involved in these operations.

EPOXY RESINS IN PATENT LITERATURE —G. Tewes

The author is concerned with the confusion that reigns in the use of the term "Epoxy". At present any copolymer with an epoxy radical or any resin system that has epoxy in it is called "Epoxy". A very exacting analysis of what the term epoxy implies is presented. The author explains in detail to what extent a resin can be modified by copolymerization air condensation and still be called epoxy. An extensive analysis of the international patent literature relating to epoxies is given. The following sub divisions concerning epoxy patent literature are made: General production and techniques; epoxies with halogens; epoxies indicating a thio group; hardening of epoxies.

PLASTICS AND PLASTIC PRODUCTS IN FRANCE'S FOREIGN TRADE FOR 1956 —Erwin Stein

A thoroughly documented article on the production, export and import of all plastic raw materials and finished products, in France for the year 1956. The figures are given in quantity units and in France.

★

DER PLASTVERARBEITER

January, 1957

Abstracter: Leo Fischer

ELECTRO MECHANICAL DEVICES TO ATTAIN AUTOMATION IN INJECTION MOLDING —Rudolf Rohen

Accessories now available for installation in injection molding machines are discussed and indications are given how far automation can be carried with available devices. Besides the usual automatic characteristics of standard injection presses the author suggests the installation of mechanization for automatic weighing; temperature control of molds; safety controls to prevent the mold from closing when mold is not completely empty, for instance when a molded piece or sprue gets stuck. It it stated however that when inserts are used complete automation is so far not feasible. Some of these controls are activated by photo electric devices.

SURFACE HARDENING OF COMPRESSION AND INJECTION MOLDS—Dr. W. Haufe

A thorough and detailed description of shop practice in hardening molds as well as fundamental physical and chemical principles are given in this article. Special points are made on how to avoid failure. Three methods of hardening steels are given: nitriding, annealing and carbonizing. In nitriding a sealed oven with temperatures at 500 C under ammonia gas pressure is used and the mold exposed for 100 hours. Hard nitrides with the chromium and molybdenum are formed to a depth of .8 mm. This is the most widely used hardening

Plastverarbeiter . . . (con't.)

method used in England and France. The mold is exposed to the least strains and a very high finish is possible on the surface.

In annealing at least 3 to 4 mm. must be added to all dimensions for subsequent grinding as the 600 C treatment for two hours is likely to warp the mold unless cooled slowly and with great care. Carbonizing is also discussed in great detail.

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PLASTE AND KAUTSCHUK

December, 1956

Abstracter: W. Brenner

AUTOMATION IN THE RUBBER INDUSTRY
—O. Habicher

The present status of attempts towards greater automation in the rubber industry is reviewed with special emphasis on better mixing technology, the manufacture of semifinished products, and improved finishing process. The optimum possibilities for automation are believed to be in the tire industries. The recent development of tubeless tires in Germany made use of considerable automation in process design and paint lay out with very satisfactory results.

EXPERIMENTS ON THE CONDENSATION OF β-NAPHTOL WITH ALDEHYDES
—W. Strubell

The paper describes experiments on the condensation of Bnaphtol with aldehydes. Condensations in an acid medium with aldehydes does not proceed analogously to phenolic condensation reactions. With naphtols the hydrogen of the hydroxyl group plays an essential role. Bnaphtol does not yield direct condensation products with aldehydes but forms acetal-like combinations which then reset further to form isomeric compounds or their anhydrides. Two moles of Bnapthol and one mole benzaldehyde reset in the pressure of sulfuric acid to produce crystalline materials with a melting point of 190 C which are easily soluble in chloroform and other organic solvent media. Resinification could not be attained even after heating at elevated temperatures. Acetoldehyde and formaldehyde do not result in resinification either. Experiments with acetone were equally unsuccessful.

Numerous experiments were also carried out in an alkaline medium. Dioxydinaphtylmethane produced brittle easily soluble resins which had a dark red color. Hexamethydenetetramine additions resulted in alcohol insoluble resins.

SILICONES IN THE TEXTILE FIELD
—H. Reuther and C. H. Schneider

The basic chemistry of silicone compounds is briefly outlined as an introduction to a timely discussion of the many and varied applications of these versatile polymers in the textile industries. Most of the subject matter of this article has been repeatedly described in various American technical publications within the past two years. Silicone laminates are considered and the manufacture of silicone fibers is discussed based on the status of the present technology in this field.

COMBUSTION TEMPERATURES OF LIQUIDS
—K. Thinuis and P. Reenze

The paper presents data on the combustion temperatures of various solvents and plasticizers which are in common use in Germany. Equipment for measurement of this property is described and accurately evaluated.

★

GREAT BRITAIN

TRANSACTIONS & JOURNAL OF THE PLASTICS INSTITUTE

October, 1956

Abstracter: L. H. P. Weldon

RIGID P.V.C. DEVELOPMENT (PP 303-325).

—L. H. P. Weldon (Brit. Geon Ltd., Res. & Dev. Labs, Barry, Glamorgan, S. Wales, England).

The early uses of PVC, starting with the patents of Goodrich and Carbide & Carbon in 1933 and 1934, involved considerable plasticization to render the material processable. The very characteristics which made PVC difficult to process are now highly dessirable in these of rigid PVC and copolymers thereof. These properties are predominantly its chemical insolubility and inertness, and its moderately high fusion temperature. Other outstanding properties are good weatherability, moisture resistance, flame retardancy, electrical characteristics, and color range. It is also a relatively low cost resin and possesses a noteworthy versatility in processability. The following procession methods are briefly covered in the article: primary compounding, fabrication of mill sheet, extrusion, calendering, injection moldirg, forming, molding, welding, and machining. One of the more important advances has currently been the process of injection molding.

The three properties of greatest significance in the processing of rigid PVC are its softening temperature, plasticity, and heat stability. These are all inter-related. A number of graphs are presented illustrating the variations in these properties with specific viscosity of the resin and % comonomer present in the case of PVC copolymers. One remarkable experimental disclosure is the fact that rigid PVC has a maximum tensile strength when lightly plasticized (up to 10% plasticizer content). Lightly plasticized PVC processes somewhat easier than unplasticized material.

Recent applications of rigid PVC are discussed. These include wire insulation, pipes, water ducts (particularly PVC-styrene-acrylonitrile copolymer), building components (gutters, roof coverings, etc.). One of the outstanding uses of rigid PVC is in the manufacture of records. The detailed requirements for this application are discussed at length. An extensive bibliography is included with the paper.

RECENT DEVELOPMENTS IN THE USE OF LAMINATES FOR PRINTED CIRCUITS

—D. Lidgley (Thomas de La Rue & Co., Ltd.)

Mechanization and miniaturization in the electronic industry have pointed up the advantages of using printed circuits. Of the latter techniques, the one employing a metal clad plastic laminate has received the greatest acceptance because of ease of control and versatility. Design of the printed circuit requires careful attention to such factors as general layout and dimensions, electrical properties of the metal (most usually copper foil) and plastic materials, printing techniques, temperature resistance (for unit soldering), mechanical properties, (particularly dimensional stability), etc. The two major duplication methods employed are (1) The technographic method. This is essentially a lithographic printing process in which the resist ink layout is printed onto the metal clad surface. The resist ink is covered with fused bitumen (Dragon's Blood) to seal pin holes. The uncoated metal is then etched away (3-4 minutes in conc. ferric chloride solution for a .9015" thick foil), the plate washed, and the resist print dissolved away leaving the completed circuit. This method is superior to silk screen printing, but costlier. (2) The photographic method. An emulsion superimposed on a resist layer is exposed to a negative of the circuit. The print is developed, the unexposed resist washed away and the foil etched to complete the process. The photo method is also applicable to the production of circuit components such as capacitors, inductors, and resistors. Epoxy, silicone, and teflon laminates are used for purposes of low loss and high temperatures.

SECTION NEWS

Edited by
Charles P. O'Donnell
Monsanto Chemical Co.
Springfield, Massachusetts

Newark

Speakers Present Information On Cycolac and Penton

Robert A. White

The March meeting was opened by section president Bob Hohen who requested that members give serious consideration to the selection of topics for presentation at the 1958 National Convention.

Ray Mistretta, chairman of the Professional Activities Committee, reported on the brisk business enjoyed by this activity. Members were encouraged to avail themselves of the services offered.

Plans were announced on the Annual Outing of the Section. Co-chairman John Lombardi promised a most eventful day for section members at the Mazdabrook Country Club on June 12th.

Announcements were made of the appointment of Don Biklen as assistant to Pete Simmons during his term as National President; and of the appointment of Bill Willert to the executive committee of the 1959 National Convention.

A new innovation in the meeting was the presence of the Host Committee. This group, identified by a Host Badge, will serve as official hosts to newcomers and guests.

The first speaker of the evening, Mr. Howard H. Irvin, Technical Director of the Marbon Chemical division of Borg Warner, presented Cycolac, a new rigid, high impact thermoplastic. This material is offered in three grades, "H" for injection molding, "L" for calendering and extrusion; and grade "Lt." possessing good long term characteristics and being useful for flame retarding formulations.

Generally Cycolac, having a density of approximately 62 lbs. cu ft., exhibits impacts of 5 ft lbs. per inch of notch; a 90 rockwell hardness and a strength to weight ratio only exceeded by nylon. At low temperatures Cycolac retains its impact strength where most competitive materials fall off. In stress strain curves it resembles steel in that it demonstrates a definite yield point. Additional desirable attributes of Cycolac are resistance to creep, good electrical properties, approval for food exposure usage, and, upon aging, no degrading in tensile, and only a slight drop in impact and elongation during the first four months with no further reduction in values upon additional exposure.

In finishing and assembly, Cycolac is versatile and tough. It may be machined, drilled, welded, used in force fit and most commonly adopted assembly techniques.

The second speaker, Mr. E. Cronin of the Development Division of Hercules Powder Co., introduced the latest Hercules discovery, **Penton.** This polymer, currently in the development stage, is now available in small quantities at $6.00 a pound. Volume production will bring the price into a $2.00/lb. range.

Penton, a chlorinated product in stable form containing approximately 45% chlorine; provides moldings strain free, accurate to tolerances and dimensionally stable. Injected into a die in an amorphous state, Penton relies on crystallization for setting up to the hardened state, producing stress free moldings. In going from a melt to a solid, it undergoes an extremely low volume change.

Penton exhibits exceptional dimensional stability under adverse conditions, a good balance of properties, fair tensile strength, elongation comparable to nylon, and chemical resistance at 100°C in the same area as flurochlorohydrocarbons. In electrical properties it is rated well, not quite approaching styrene, but suitable to most applications.

Areas of application for Penton are electrical rod stock, wire applications, gear and bearing retainers requiring exceptional tolerance, as monofilaments into rope, and as coatings for corrosive atmospheres. It is expected that the areas of brass and other metal alloys will be invaded by the desirable properties of Penton.

The final speaker of the evening was Mr. R. H. Brandt, Vice President of Fiberfil Corporation. Mr. Brandt presented the concept of glass fiber filled injection molding compounds.

This remarkable material is supplied in pellet form containing 30 to 35% glass by weight and 12 to 14% by volume. Fibers are in bundle form containing 10,000 to 30,000 monofilaments. Bundle retention during molding is reflected in high impact values. Bundles are dispersed by high velocity through gating. This also enhances finish. Control of velocity can offer a wide range of properties. Notched Izod Impact increases as the temperature decreases. This is unique when considering the properties of molded styrene.

Type of bond is most important. Fiber glass is not inert from a colloidial chemistry standpoint. It is believed some polar orientation is effected on the thin film of the plastic surrounding the monofilament. Relatively stress-free moldings are produced, each monofilament acting as a stress release point. Some of the characteristics exhibited are low water absorption, excellent moldability, high impact and improved high temperature properties. No abrasive problems are encountered in the molding of these materials.

This interesting program was presented to 109 members and guests of the Newark Section. The meeting closed with the awarding of door prizes.

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Northern Indiana

Demonstration In Impact Resistance

Leon J. Page

The Northern Indiana Section held its second monthly meeting of 1957 on March 12 at Manochio's restaurant in Ft. Wayne. (The second Tuesday of each month has been established as the regular time of meeting.)

A brief discussion of several new plastic materials under consideration by United States Rubber was given by Dr. E. T. Rainier, Development Specialist at the Ft. Wayne Plant of U.S. Rubber. Dr. Rainier's forceful demonstration of the impact resistance of these materials was more damaging to the wood anvils than to the plastic materials tested. He appeared to be greatly angered at the stuff by the way he rained hammer blows on a new material named aptly "Dynasorb."

After peace and calm were restored a short business meeting was called by the new President, Leon J. Page of United States Rubber, who introduced the new officers on his staff for 1957 to the members, William G. Leichner of Farnsworth Electronics, Vice President and Chairman of the Publicity Committee; Harry B. Bolson General Electric, Secretary-Treasurer; and Max M. Lee General Electric, Chairman of the joint program-house committees. Chairmen of other committees introduced were George Kelsheimer, William Wareham, James Martin, and Charles Cougill.

Attention was then directed by President Leon Page to the Citizen-Engineer Citation awarded to Wayne I. Pribble by the Committee of Ft. Wayne Engineering Societies at its annual Engineers Week banquet. Wayne I. Pribble, well known as a National Director of the Society of Plastics Engineers, was selected for this honor primarily because of his many faithful activities in church work throughout the Northeastern Indiana area and for the prominent part he plays in civic activities as well.

The very interesting topic of New Developments in Injection Molding was then presented to the members by Mr. Robert Dahl of Dow Chemical Company, a member of the Detroit Section of S.P.E. Mr. Dahl introduced many thought-provoking ideas on injection molding techniques including the helpful effects of relocation or addition of heating equipment at various locations on the cylinder and nozzle of injection machines.

After illustrating many points in his talk with slides, Mr. Dahl exhibited a series of extremely difficult-to-make motion pictures of a mold equipped with glass ports to allow observation of the actual filling of the mold cavity with various injected thermoplastic materials. The effects of jetting, material shrinkage, sink marks and many other problems encountered in injection molding were observed and studied.

New York

New Epoxy Resins Explained

Jim Dugan

The Reinforced Plastics Group of SPE's New York Section met on January 30 at Tufaro's Restaurant, Corona, L. I., N. Y. Jerome D. Bassin, epoxy technical service manager for The Borden Co., addressed the members and guests on "New Epoxy Resins." An abstract of his talk follows:

Epoxies have been commercially available for only about five years. They include four basic types: the Bis-Phenol-A resins, which account for about 95% of the commercially-available epoxy resins; Novolac epoxies, which can be cross-linked to give resins of higher stability and strength; glycerine epoxies, which have a very low viscosity but little heat and water resistance; and the peroxide epoxies, which are expected to be the least costly.

Mr. Bassin also covered converters for epoxy resins, and accelerators for epoxy-converter systems. The former includes both room temperature and elevated temperature materials, and the latter includes anhydrides and amines. Resin specifications were considered in some detail.

Western New England

Engineering House Of The Future

C. P. O'Donnell

The March 6 meeting of the Western New England Section of the S.P.E., under the Technical Chairmanship of Wesley S. Larson of DeBell & Richardson, featured the M.I.T. Department of Engineering and Construction Professor, Frank J. Heger, Jr., as the evening's speaker. Mr. Heger delivered his talk—"Engineering the Monsanto House of the Future"—after the usual monthly dinner in the Bradley Field Administration Building's Terrace Dining Room.

Prior to Professor Heger's speech a short business meeting was conducted by Section President Lou Gustafson of Prolon Plastics. At the time it was pointed out that a sectional technical meeting, "Plastics in the Electronics Industry," sponsored by the Eastern New England Section, was to be held June 14 at the Lowell Textile Institute.

In introducing his talk for the evening, Professor Heger remarked that he would not attempt to be comprehensive but would consider plastics in construction mainly from the structural engineering viewpoint. Because of his close association with Professor A. Dietz and F. J. McGarry, working on the design and engineering of Monsanto's House of the Future, the professor illustrated structural uses of plastics with a full discussion of the Monsanto House of the Future. Slides were used to compare plastics with conventional building materials in tensile strength, modulus of elasticity, thermal expansion and temperature sensitivity.

The speaker went on to outline the important considerations relative to the engineering properties of plastics. Strength properties such as tensile, compressive, and shear strengths; strength-time relation such as creep and rupture; as well as stiffness, thermal expansion and conductivity, temperature tolerances, transparency, durability and flamability were also discussed.

The M.I.T. professor then covered architectural aims as expressed in the House. He pointed out that the M.I.T. designers attempted to use plastics in a form suitable to the materials and also develop a design not encumbered with preconceived ideas. The engineering aspects, besides meeting the usual structural criteria, also considered related items such as demountability and size of the pieces, to keep within shipping restrictions.

At this point Professor Heger discussed the technical details of the components of the House, and their design data. To underscore the data accumulated he described the full scale test which was run on prototype pieces of the House before construction was started.

In concluding, the M.I.T. speaker made some forecasts for the future. He expressed a belief that sandwich construction looks most promising as a future use for plastics in the building fields. However, he explained, indications were that there was a need for connectors and sealants with, perhaps, extruded plastics shapes serving as the connectors. There was, according to the professor, a need for test and research data in addition to materials and fabrication cost data. For example, curved shapes tended to run to a high cost figure because of the large size mold. In line with these needs, it was also remarked that building codes would have to be revised to permit fuller use of plastics in construction.

After the usual question and answer period and a vote of thanks to the speaker, the meeting came to a close.

Binghamton

Applications Of Epoxies

L. N. Chellis

February Meeting

The Binghamton Section of SPE held its monthly dinner-meeting on February 26th at the Vestal Steak House.

There were 52 members and guests in attendance.

Our Vice-President, Mr. Emory Slaght presided. Guests were Al Rennie, Daystrom Corp.; Bob Coyne, Consolidated Molded Products; Werner Shink, Ansco Corp.; Bob Skinner, Consolidated Molded Products; Dick Park, Houghton Labs; and Don Wolcott, Houghton Labs.

After a brief business session, Mr. Slaght introduced the speaker, Mr. Russell Houghton of Houghton Laboratories, Olean, New York.

Mr. Houghton discussed epoxies and their applications. He briefly covered the patent situation and the chemistry of the epoxies.

The various available curing systems, including polyfunctional aliphatic amines, aromatic diamines, and organic acids or anhydrides were discussed in detail. The speaker stressed the important role played by the compounder or formulator in tailoring the epoxies for a given application.

The speaker demonstrated the applications by means of samples. Of particular interest to the group were bobbins for precision wire wound resistors, cast slip ring assemblies, three dimensional cast models for photo-elastic analysis, potted coils and transformers, injection cavities for development parts, vacuum forming molds, and a sample rod of polyurethane rubber modified epoxy which retains its flexibility at -90°C.

A spirited question and answer period followed Mr. Houghton's address.

March Meeting

The Binghamton Section held its monthly dinner-meeting on March 28th at the Vestal Steak House. There were 54 members and guests present. Our guests included John Lombardi, Shaw Insulator Co.; Jack Stanton, American Cyanamid Co.; George Rheinfrank, Glaskyd Corp; Burt Wing, Garry Bordener and Emery Sescycle, Plaskon Division of Barrett Chemical Co.

Our speaker was William J. B. Stokes on the subject of "Engineering of Molds Using Electroformed Cavities". Mr. Stokes covered in detail the considerations which go into design of mold cavities for electroforming. Since most thermosets stain nickel, cavities should be chrome plated when these materials are used. They do not have to be plated for thermoplastics. Electroformed cavities allow for perfectly matched curved parting lines, intricate details, sidewall details and undercuts, accuracy and efficient cavity spacing.

Mr. Stokes illustrated his talk with a number of interesting slides and exhibited several molds.

Plans are well-underway for our 1st Annual Dinner-Dance to be held on May 18th.

The Binghamton Section now numbers 61 members or members in process. Our goal is a section of 100 members by September of this year.

Cleveland-Akron

Quality Control Product Sampling

Robert L. Larsen

The Cleveland-Akron section meeting for March 11th was held at the Spanish Tavern in Brecksville, Ohio and a double feature was the EXTRA for the evening.

Mr. Delmar C. Dague, Quality Control Engineer, of the Hoover Company, North Canton, Ohio, accompanied by Mr. L. F. Summerill, also of the Hoover Company, was the speaker for the evening and spoke on the subject — QUALITY CONTROL-PRODUCT SAMPLING. Mr. Dague, using working samples, discussed the methods for sampling and various rules and definitions pertaining to good product sampling. Questions from the floor were answered following the paper.

The EXTRA for this meeting consisted of a movie furnished by the Illuminating Company and revealed the enormous business potential for the Northeastern Ohio area with the development of the new proposed Seaway.

The large attendance all profited from the meeting, but for those who were unable to attend, the following schedule for the forthcoming meetings, all with EXTRAS, should be of considerable interest. May meeting will be a plant visitation to the Hoover Company at North Canton, Ohio, plus a dinner dance later in the month. June is making itself ready for the big Golf Outing so make your plans for these meetings.

All of the above is made possible by the hard work of your present officers and the selected committees. They have set their sights high for this year, have held several board meetings, and in addition to the regular planned meetings, now announce that in October, the Cleveland-Akron section will sponsor a Regional Technical Symposium for one day on "POLYETHYLENE." Additional information on the symposium will be released at the forthcoming meetings as well as more detail on the regular meetings. Your section officers deserve a hand for their hard work and the best way to show it is to be in attendance at your meetings.

Miami Valley

Members Tour Chevrolet Plant

A. P. Young

March Meeting

About fifty members and guests of the Miami Valley Section toured the Norwood, Ohio, Chevrolet Assembly Plant on the evening of Thursday, March 3rd. They watched the complete assembly, which starts with the bare frame, and ends with the automobile being driven away under its own power.

This plant, operating on a two-shift basis with about thirteen hundred employees, finishes about forty cars per hour. The complete assembly operation takes approximately one and one half hours. The bare frame is removed from a railroad car and put on the assembly line, the basic parts are added as it moves down the line, and finally the body is lowered and fastened onto the frame. A number of checks and tests are made from time to time to insure that all parts function properly, and finally the completed car is driven away. Everyone was somewhat intrigued by the amount of planning which must be necessary to see that the parts which arrive agree with the plans, and that a red car doesn't end up with blue wheels, or something like that.

June Meeting

Plans for the annual June picnic are going forward, and a very enjoyable affair is anticipated. This will be held on Friday, June 7th. Negotiations for the use of a course for those who like to play golf are in progress, and announcement of the place should be forthcoming shortly. Meanwhile mark this date on your calendar and keep it open.

Personal Notes

At the time this is being written, our publicity chairman, Dick Lyday, Inland Manufacturing Division, General Motors Corporation, is enjoying a two week's vacation in Florida. He must have had some advance notice of this weather we have been having.

Pioneer Valley

Problems Met In Building Cylinders

Jack Perkins

Mr. A. Reynolds Morse, President of the Injection Molders Supply Company in Cleveland, Ohio, was guest speaker for the Pioneer Valley Section of the Society of Plastics Engineers' March 14 meeting held at the Wachusett Country Club in West Boylston, Massachusetts.

Mr. Morse reviewed some of the problems encountered in building extra capacity replacement cylinders designed to meet specific molding conditions beyond the scope of the all-purpose standard heater usually supplied with a standard injection machine. The speaker pointed out that both the variety of thermoplastics now available, and their much improved heat resistance, demand special-purpose cylinders designed to meet specific melting points and adapted to contain them safely, prior to injection, without decomposition.

Nearly all IMS extra capacity replacement cylinders are equipped with heater bands raised at about 40 watts psi. An independent survey of most major existing heating cylinder types made by Thermel, Incorporated reveals that only IMS cylinders have the ability to safely dissipate the 40 watts psi of heat.

Mr. Morse further pointed out that a great deal of trouble has been encountered currently on one make of machine because some manufacturers felt that if a little heat is good, more must be better. He further stated that some press makers increased wattage without considerations of other pertinent factors with disastrous results in many shops, both to molded articles and to the cylinders themselves, where downtime has run into an all time high from defective heaters.

"I doubt," the IMS president said, "if any original equipment maker has ever studied this wattage problem thoroughly or taken detailed consideration of this matter of watt density. At least the IMS analysis of a great number of original equipment cylinders show that no two manufacturers came within a hundred percent of agreeing with each other on the point. Cylinders are uniform in basic design no matter what press they are used on. Therefore, we are able to make exhaustive comparisons of all press factors."

Another important discovery arrived at by Thermel was that many original equipment manufacturers, by different attempts to make cylinders "all purpose," have too much wattage supplied for the areas and sections involved. Long, thin tubular heaters were proved to be severely overloaded in many cases and capable, not of proper plasticizing, but only of degrading the material passed through them, Mr. Morse said. Wattages ran up to 35 to 38 psi when they should have been figures at 25, or about the heat input of an extruder, if the plastic so produced was expected to retain its advertised characteristics of toughness, craze resistance, etc.

Mr. Morse went on to say he felt that the day is fast approaching when the molder will find it less costly to change heating cylinders than to try to mold every powder in the same all-purpose chamber. The cost of changing from nylon to polyethylene or vice versa, if a record is kept of the scrap so generated, illustrates there is real economy in specially designed heaters reserved for one use on special molding powders. Not only would the wattage of the bands be different, but the wall sections in inventory of plastics would be radically modified on a cylinder built just for nylon or polyethylene.

That alert molders see this trend to special purpose cylinders is illustrated by the fact that one out of every eight replacement heaters that I.M.S. manufactures is now being built for a special molding problem, and they expect this trend to increase.

Eastern New England

Forum Held On Vinyl Stabilizers

Charles P. Pechulis

A joint dinner meeting with the Society of the Plastics Industry, (Boston-Providence Chapter) was held at the University Club in Boston, Mass.; approximately two hundred members attended.

Mr. David Towler, President of the Eastern New England Section of the Society of Plastics Engineers, announced that the S. P. E. Regional Technical Conference will be held on June 14, 1957 at the Lowell Institute of Technology, Lowell, Mass.

Mrs. George Laaff, Research Director of the Bolta Company, acted as moderator for the program on Vinyl Stabilizers.

The first speaker, Mr. Norman Perry of the Argus Chemical Company, spoke on the progress of barium and cadmium as a stabilizer with the addition of various salts and zinc compounds, in order to achieve strength, color stability, and moldability.

Mr. Al Scarborough of the National Lead Company gave the history on the development of lead as the first stabilizer up to the present day achievement of organo lead compounds.

Mr. Gerry Mack of the Metal and Thermit Corporation spoke on organo tin stabilizers from which water clear, as well as light stable, and good weathering vinyl compounds are obtained.

An open forum ended the meeting with satisfaction and it was resolved that no matter what the stabilizer, its importance in the control of quality production must be considered in order to get the most satisfactory combination in what is desired.

Central Indiana

Tour Conducted By Western Electric

C. R. Smith

The Central Indiana Section turned out a record 200 guests and members on March 26th, to attend a plant tour at the Western Electric Co. of Indianapolis.

After a hearty meal, served with the compliments of Western Electric, visitors were conducted through the plant in small groups under the guidance of 27 Western Electric employees.

Of immediate interest to the group was the thermoplastic and thermosetting molding operation. The magnitude of this installation is best illustrated by their daily production figures of 32,000 complete telephone units as well as a variety of other telephone system components. The latest and most modern techniques and equipment are in evidence throughout the plant, from the 12 vertical injection presses to the double shot injection molding of telephone dials. The materials handling system is also unique, reducing labor to a minimum through the use of in plant conveyor and screw feed mechanisms connected to large storage silos.

Visitors also had an opportunity to observe the high speed assembly lines turning out finished products with split second timing.

Everyone attending is indebted to Section Director Keith Weston, Chief of Plastic Molding Engineering Dept. at Western Electric, and his associates for a most interesting and enlightening evening.

Section members should note that the date of our May meeting has been moved up to the 23rd for the convenience of our speaker, Mr. Robert Sharpe of Socony-Mobil who will discuss hydraulic maintenance. There will also be a timely discussion of fuels, cars and drivers participating in the Memorial Day "500" race by Mr. McMahan, a fuels specialist, and a film of the 1956 race.

Officers and Committeemen Are Announced

A. L. Therrien

Officers and Directors for 1957: President, R. L. Hayes; Vice President, George A. Hayslip; Secretary, Alfred L. Therrien; Treasurer, George F. Erdle. National Director is Robert M. Stroman, and Past President is C. Burton Wing.

Section Directors are Victor F. Serrell, 1955-1957; C. Burton Wing, 1955-1957; Herbert B. Collins, Jr., 1955-1957; Richard Hayes, 1956-1958; Lewis E. Hamel, 1956-1958; George A. Hayslip, 1956-1958; Olin H. Deyle, 1957-1959; Merton R. Turrell, 1957-1959; Robert F. Bunker, 1957-1959.

Membership Committee: C. Burton Wing, Chairman; Clarence F. Van Epps, R. T. Peterson.

Publicity Committee: Lewis E. Hamel, Chairman; George A. Neward.

Educational Committee: Gerard C. Delaire, Chairman; Norbert G. Zink, Richard A. Lehman.

Credentials Committee: Vernon M. Howe, Chairman; Gerard C. Delaire, Jack Bent.

Auditing Committee: John H. Beach, Chairman; Waldo B. England, Floyd Redmond.

Seminar Committee: Victor E. Serrill, Chairman; Charles J. Williams, Ralph C. Walsh.

National Director: Robert M. Stroman.

Nominations for 1958: H. B. Collins, Jr., Chairman; Floyd Redmond, M. Turrell, J. Dabbs, C. B. Wing.

Society of Plastics Industry Liaison Committee: Harold F. Bardwell, Chairman; Ernest W. Goral.

Professional Activities Committee: Robert F. Williams, Chairman; Harvey M. Bryans, Charles J. Levine.

Program Committee: Gordon F. Connelly, Chairman; Gene F. Smith, Nicholas D. Commisso, Joseph J. O'Hearn, Robert F. Bunker.

Society of Plastics Engineers Pioneer Plastic Engineering Consulting Staff: Garson Meyer, Chairman; John Woodruff, John F. Spitznagel, George A. Peck, Arthur F. Pundt, Harry V. Steele, James B. Neal.

House Committee: Charles Lennon, Chairman; Howard J. Hill, Jr., Olin H. Deyle, Raymond A. Lander, Jr.

Supramica

Development of a new moldable ceramoplastic insulating material, known as Supramica 560, which will withstand continuous operating temperatures in excess of 500°C, has been announced by Mycalex Corporation of America.

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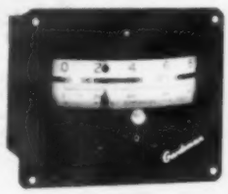

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Model JS Series
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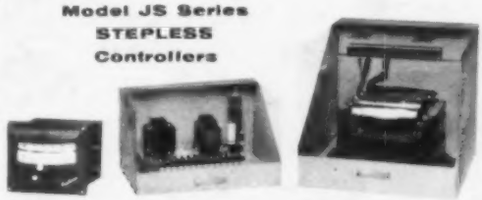

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Molds for Automatic Molding

Glenn A. Tanner

The March meeting of the RISEM section was held March 28th at Wayland Manor in Providence, R. I. An exceptionally large turnout of about 75 persons dined with, listened to, and applauded Mr. John A. Kavanagh, Executive Vice President, of the Standard Tool Co. of Leominster, Mass., who spoke on automatic molds for injection molding and their cost.

In the absence of both our President and Secretary, the meeting and its arrangements were conducted by our hard-working ex-president, Mr. Edward Rose of Plastics Engineering Co., Pawtucket, R. I. and our able Vice President, Mr. Charles Chrones of Hassenfeld Brothers, Inc., Central Falls, R. I.

Announcement was made about the first of the annual Technical Symposiums, sponsored by the five New England Sections. This conference, originally scheduled for January, will now be held at Lowell Technological Institute, January 14, 1958. Subject of the conference will be Plastics in the Electronic Field, and it is planned to cover all possible phases of this topic.

Mr. Chrones presented a transistor radio to Mr. Edward Rose. This gift was given by the Section to Mr. Rose in appreciation for, not only the excellent job he did this past year as our president, but also in appreciation for the spirit and leadership he has injected into our organization for many years.

Mr. John Kavanagh began his talk with an analysis of design of automatic molds for injection machines. He stated emphatically that an automatic injection machine will not operate right unless the mold is right. Since the mold is the heart of the automatic operation, it pays to spend time and thought, as well as the extra money necessary to develop a mold which will furnish fool-proof operation, which is required of automatic molding. It is impossible to scrimp and save on the production of an automatic mold. It must be positive and it must be done correctly.

Mr. Kavanagh advocated that the best procedure to follow in making a mold automatic is to contract to have the mold produced for semi-automatic operation. After this is done, it should be tested semi-automatically and then decide how to make it run automatically. If this is not done, it will be necessary for the tool maker to add an estimate of 10 to 20 hours over the regular mold production cost, as a safety factor in the production of this automatic mold.

The requirements for an automatic mold are: (A) mold must be right and rugged, (B) it must have a positive stripping mechanism for the cavity-either ample ejector pins or a stripper ring, (C) it must have positive ejection for the sprue and runner. This latter is often the most difficult to solve in automatic molds, because the sprue and runner cool more slowly because of their thickness, they have many corners to catch on lower projections, and usually they have the greatest length. This problem can be solved by use of a hot runner mold, although, oftentimes, people are skeptical of this system, and it is somewhat costly. The problems can be solved by use of a three part die, but it is still necessary to concentrate on the ejection of the sprue and runner.

Mr. Kavanagh explained how all of these factors tend to increase the cost of an automatic mold. He emphasized that the thing to remember is the largest cost factor in any mold is labor.

It is not uncommon for a molder to request that a mold, which was quoted for 16 weeks be finished in 8, if at all possible. This, of course, means overtime for the tool makers at an increased cost. Not only does this run the cost of the mold up, but it must be remembered that any craftsman can only work extra time at something like 20% less efficiency. It, therefore, costs more per hour for less work per hour accomplished.

On any mold quotation, it would be advantageous to use the standard specification sheets, which are available, when requesting a quotation. Doing so will more nearly allow a comparison between quotations from different mold sources. Without the use of these standard specifications, there are a thousand variables in construction and dimensions, which can greatly effect the cost of the mold.

Mr. Kavanagh emphasized that a good mold might cost more but would amply repay this cost in a saving in cycle time, down time, and rejects. He stated that it is better to cut down on the number of cavities than it is to cut down on the quality of the mold.

After his speech was finished, Mr. Kavanagh was deluged with questions from the audience and it was found necessary to cut the question and answer period short in order that he might catch his airplane.

Hassenfeld Brothers, Inc., Central Falls, R. I. donated a number of door prizes, which were won by Mr. C. M. Ellis, Mr. John E. Lynch, Jr., Mr. Al Krajewski, and Mr. Edward I. Rose.

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Detroit

Plastics for "Future" Cars

Mac Nichols

The Detroit Section of the SPE held its scheduled monthly dinner meeting on March 18th at the Dearborn Inn.

The featured speaker for the technical session was Mr. Harvey J. La Douceur, Jr., Manager of the Competitive Analysis Group of the Mercury Division of Ford Motor Company, whose topic was "Brainstorming Plastics for Cars of the Future."

Mr. La Douceur stated that the primary function of his department was to determine in the forthcoming automobile models, the successful applications of established plastic materials to new uses, as well as new materials for new ideas.

"Basically," declared Mr. La Douceur, "we are classified as an Evaluation Department, where we are called upon to challenge the usefulness of a new material and determine its practical usage in its intended application. We must compare its quality, availability and cost with the part it is intended to replace. We must carefully check each facet of its functional operation to see whether it maintains the standards that have been established by the engineering department."

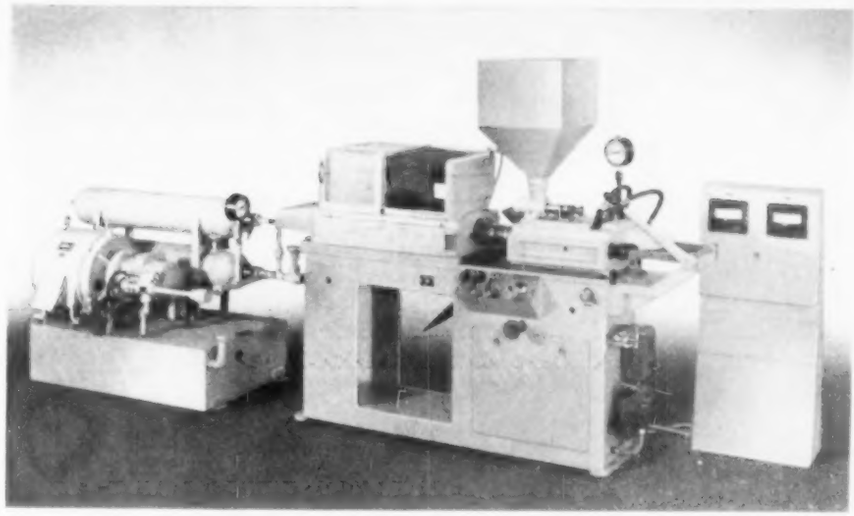
Mr. La Douceur told of the valued information that was garnered from various types of questionnaires that were sent to thousands of present customers. These surveys, when summarized, gave them important data pertaining to the usual "gripes" of the public.

"We are apprised in these reports," said the speaker, "that certain items are either too soft or too hard, too high or too low, too long or too short, too dull or too shiny, too fragile or too bulky, too dim or too bright, too round or too square, and so our true function as an Evaluation Department is put to the acid test."

That the topic was provocative was evidenced by the spirited question and answer period that followed. However the specialized qualifications of Mr. La Douceur enabled him to meet all challenges with aplomb and a stimulating evening resulted.

Duralith Corp.

Dr. Martin Sackoff has been named Director of Research of the Duralith Corporation, Philadelphia, Pa., manufacturers of plastic name and instrument plates and schematic designs. The research field covers the application of plastic and resin materials for both indoor and outdoor use.



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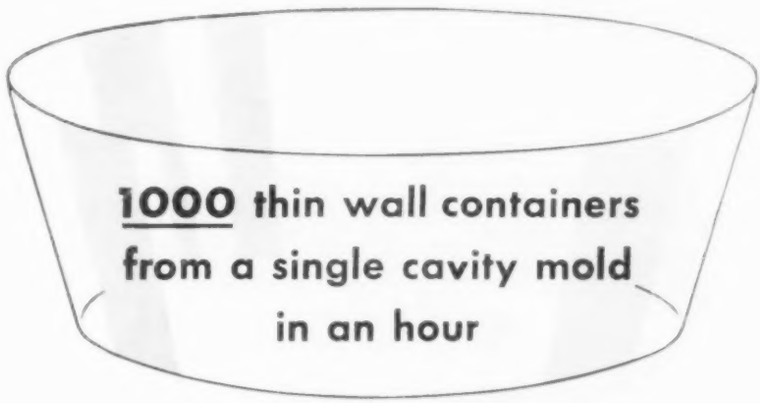

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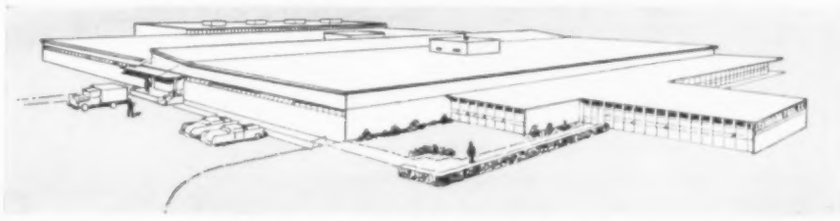

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Molding Small Parts . . .

(Continued from Page 25)

occur, following which the production molds are made. Since the full-scale production is done on the same type press, the transition from the development mold in the lab press to the production mold in the production press introduces no new variables. And while the production mold is being constructed, the development mold can often produce the initial production requirements.

Significance of low mold costs

Cost estimates for various molding methods and for various applications are not simple. Such estimates naturally include capital equipment "tied up"; mold cost and amortization rate; required production rate; inventory costs and space; direct and indirect labor; design changes in part or mold; and mold upkeep.

There is no simple rule of thumb on when to use this small press. Frequently, the deciding factor aside from the fully automatic aspect is the low mold cost. Since a part of the conventional mold has been designed into the machine itself, and since simple inexpensive mold blocks are used for the cavities, mold costs are lower. As discussed earlier, molds for the press consist essentially of cavity inserts.

For a number of reasons, the **part** cost of molding on the small unit is often higher than the cost of using large multi-cavity molds in conventional automatic or semi-automatic presses. But the **mold** costs are generally very much lower for this small press. To easily estimate the feasibility of using the small press as compared to a conventional press, a simple cost comparator has been prepared in the form of a nomograph. It requires calculation of a part cost and mold cost both for the Model 99A press and for a conventional larger press, to determine ideal production quantities, or to determine a break-even point for quantity production. By keeping in mind the mold amortization costs only, surprising savings can be realized when productions are, say, not above the quarter million mark. It is this new concept—that of having as low mold costs as possible (and we do not mean temporary tooling)—which makes this small press the unique new tool for economical molding of small parts.

Major advantages

This discussion has presented a number of successful applications of this new tool. The machine naturally has some limitations. The molded part size is limited to about $1\frac{1}{4}$" x $1\frac{1}{4}$" x $\frac{7}{8}$" deep, and in volume to $1\frac{1}{2}$ cu. in. of powder; but many small parts lie within this limitation. Not all molding compounds can be handled on the press, but the range of usable materials is still fairly wide. Where production quantities in excess of 8,000 parts per week are required, the economics have generally shown that a larger press with a single large multi-cavity mold on semi-automatic operation will prove more satisfactory. Additionally, although transfer molding techniques are generally applied where inserts are required, this machine cannot handle inserts automatically. As pointed out before, in some instances parts normally requiring inserts molded in, can be redesigned such that the inserts are applied as a secondary operation. This procedure permits the economies of automatic molding.

The major advantages, therefore, can best be summarized as follows:

1. Fully automatic (minimum labor costs, steady production, uniform quality)
2. Low mold investment (often a major factor in piece cost)
3. Ease of mold changeover (small molds, simple installation)
4. Highly practical as a laboratory press (inexpensive and rapid mold fabrication; consistent test samples)
5. Ideal as production unit (for quantities to 250,000)
6. General advantages of transfer molding:
   - —through holes can be molded
   - —more fragile part sections can be filled out
   - —close tolerance, often to 0.0005"
   - —minimum finishing costs, practically no flash

In conclusion, the fully automatic transfer press is a new tool for custom or captive molders serving the fields of radio and communications, industrial instruments, ordnance, aircraft, and others. New concepts of press design and of molding permit phenomenally low mold costs, fully-automatic operation with simple and inexpensive start up or change-over.

This new tool evolved because of a need which existed ten years ago. That need has increased with the expanding trend toward miniaturization. It is our sincere hope and belief that designers, tool makers, and molders, *working in close cooperation*, will apply this tool to create better products at lower costs.

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Plastics House . . .

(Continued from Page 41)

was tested separately. After installation in the test frame a large number of electric wire strain gage rosettes were adhered to various locations on the bent. In addition, provisions were made to measure the vertical deflection of the outboard end of the cantilever and the rotation of the cantilevered bent with respect to a vertical line at its inboard end. The outward deflection under a distributed floor load of 50 pounds per square foot was approximately 0.75 inch, well within the calculated deflection. The stress distributions in the various laminates, as determined by the Mohr's circles for stress obtained from the strain rosette observations, indicated that the stress analysis of the structural unit had been realistic and a maximum stress of approximately 1000 pounds per square inch was present under the 50 pounds per square foot load. In regard to this, an anticipated shear lag effect was noted in both the tensile and compressive faces of the hollow box-shaped section of the bent; the magnitudes of these normal stresses diminished appreciably with the distance away from the vertical sides of the bent which provided shear rigidity and sustained shear stresses. On the centerline of the floor at the inboard end, four feet in from both vertical sides or webs, the tensile stresses were approximately half the magnitude of the same stresses six inches in from the sides.

The full design load of 50 pounds per square foot was allowed to act on the floor for a period of approximately six weeks while strain and deflection measurements were periodically taken to study creep effects. No appreciable creep in the bent was detected, substantiating the choice of working stress levels as being conservative ones.

The second phase of the full scale tests concerned the upper bent fabricated with the woven roving fabric. After installation of this unit on the test frame and the attachment of strain gage rosettes, thermocouples and deflection measuring devices, a potentially critical test was performed with the upper and lower bents connected at the outboard end. It was previously pointed out that the exposure of the roof to strong sunlight, the maintenance of an air conditioned (70 F) environment inside the house and the relatively high coefficient of thermal expansion of the glass fiber reinforced polyester could combine to create thermal stresses and resultant distortions of serious magnitudes. Such conditions were uncertain to analyze since the exact temperature gradients to expect were obscure. Hence a temperature differential of approximately 75 F was created between ceiling and roof by heating the latter uniformly over its surface. The stresses so produced in the upper and lower bents were then observed and found to be within allowable limits, though of appreciable magnitudes at certain locations.

In the third phase of the testing program, a procedure often cited in municipal building codes was followed. This consisted of the simultaneous application of twice the design loads to floor and roof, with the two bents connected, for a period of forty-eight hours during which stresses, strains and deflections were measured. The assembly behaved in a predictable fashion according to design calculations during this loading cycle, exhibiting no disturbing tendency to creep or otherwise malfunction.

As is well known, the final proof of this unique structure will be established only by its service performance. The various tests performed upon the materials in it and the structural elements of it, however, have done much to create confidence with respect to its ultimate field behavior.

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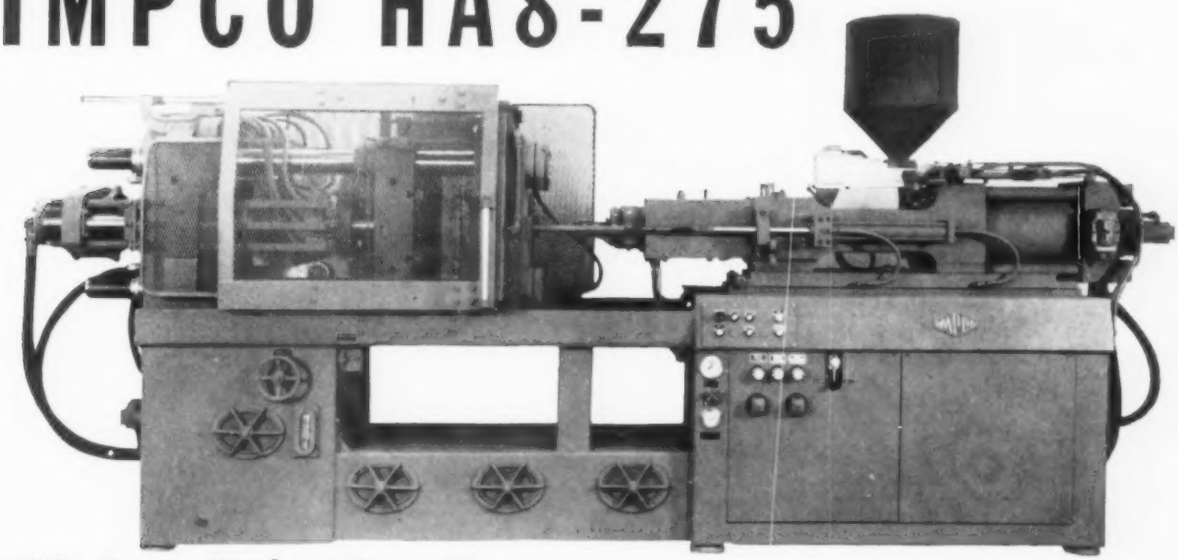

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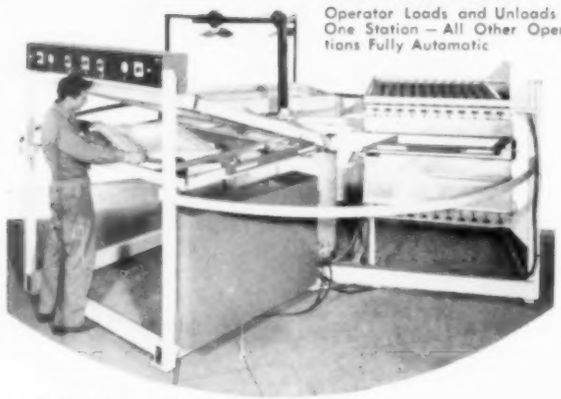

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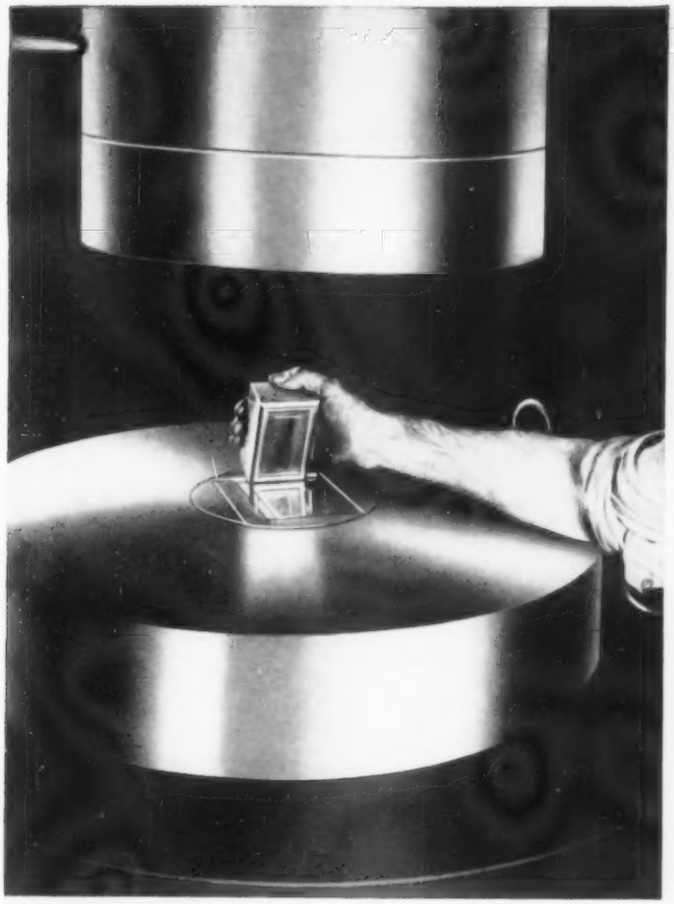

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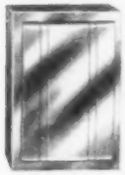
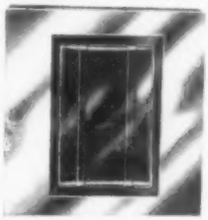


HOB

HOBBED CAVITY



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